

**DOUBLE BONUS ISSUE** ■ 90-page car repair manual ■ 14 how-to plans

MAY 1981 \$1.25

# Popular Mechanics

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**STEREO: 6 NEW PLUG-INS THAT WORK MIRACLES FOR YOUR SET**

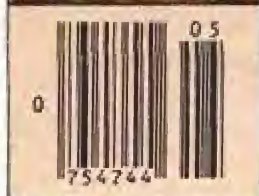
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### On the cover

The ultralight aircraft is the pride of Weedhopper of Utah, but Bill Hendrix of Mesa, Ariz., thinks his '57 Chevy Belair is a pretty exciting way to travel, too. On page 133, PM begins the 1981 Car Care Guide, which in this issue covers the critical car components you'll replace most often.

—PM photo by Rick Gayle

# Popular Mechanics

MAY 1981

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The page numbers are incorrect in the (Please turn to page—) lines of several major features in this issue. The continuations of articles beginning on pages 99 through 122 appear six pages ahead of the indicated numbers. We regret that a late-minute production problem made it impossible for us to make corrections.

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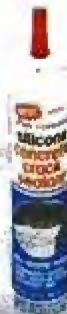


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## LETTERS TO THE EDITOR

### Everything's up to date in PM

I must compliment you on the article *Flying Fire Engine* you ran in April '79 (page 90). That your articles are informative and up to date was brought to my attention by a recent television program, which showed this same rescue vehicle. I knew more about the vehicle from your article of two years ago than I did from watching the show.

PAUL MEYER JR.  
HOWES CAVE, N.Y.

### Right river, wrong city

Regarding your article *A V8 in Skirts Beats the Mighty Mississippi* (page 111, Feb. '81), the picture captioned as New Orleans is definitely not the New Orleans riverfront, but that of St. Louis. In the background is the historic Eads Bridge, the first structure to span the Mississippi. Having lived in St. Louis for 29 years, I would recognize this riverfront scene anywhere.

JOHN E. REHDER  
ST. LOUIS

*A number of loyal St. Louis readers chided us on this blooper. Guess we were looking for the Gateway Arch.*

### Wood-stove safety pays off

We recently moved into a new home that had a wood stove installed by a previous owner. I remembered reading your article on stove safety (*How to Keep the Home Fires Burning... Safely*, page 74, Oct. '80) and realized the stove was unsafe. A layer of firebrick had been placed flush against a wood-paneled wall and the stove was set only 4 inches from it.

I tore out the brick and found a large area of scorched wood behind it. It would have been only a matter of time before the house caught fire. Thanks. You saved our home.

J. J. HUTSON  
ELIZABETH CITY, N.C.

### Illuminating suggestion

In your article *Add a "Reminder" Lamp to Your Light-Switch Panel* (page 60, Jan. '81), the procedure calls for connecting a neon lamp between the load side of the switch and the ground circuit (the switch box). Such deliberate introduction of current into the ground circuit is in violation of electrical codes and safe wiring practice.

If the neutral wire is not available,

*(Please turn to page 76)*



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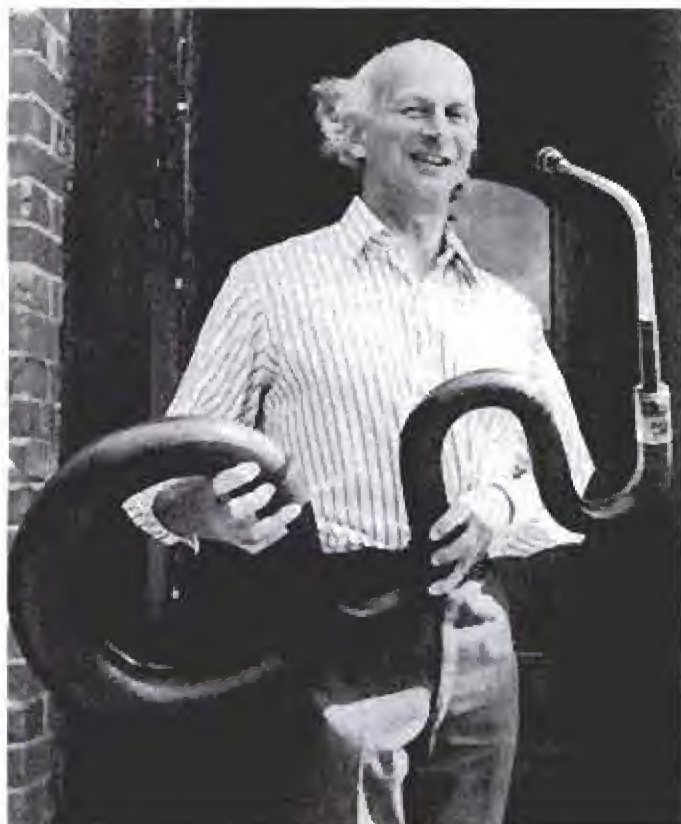


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## PM's Whatsit

Looks like this gentleman has come up with an automatic device which protects the bearer from sudden loud noises by extracting lint from his pants pocket and blowing it into his ear. That's what it looks like, but that's certainly not the story. To take note of the facts, turn the page.

## Some front-end load

Okay, behemoth buffs, for the record here is the world's largest hydraulic excavator. This bouncing beauty is put together by O & K, AG, in Dortmund, West Germany. She's got interchangeable front buckets ranging from 17.5 to 30 cubic meters, depending on the density of the material you want to scoop up. The engine output is 2352 hp, and the loading arm can dig up to 50 feet down or reach straight out to 90 feet. The driver's eye level in the cab is 20 feet above ground. With each track driven by its own axial piston motor, she turns on the literal dime. Four million takes her off the showroom floor.



## *Judgin' from the tracks, I'd say it can't be human*

Regular readers of this column are aware of our ongoing belief that the quickest

way to achieve financial security today is to come up with a really bizarre-looking golf aid. Leading this year's pack is something that looks like an unfinished skateboard. Designed to teach "proper leg placement" for those towering drives off the tee, the device was invented by Phil Krick, a club pro from Louisville. Krick will sell it by mail—even offers a "female version"—for \$19.95 plus \$2 shipping (Golf Training Aids, Box 6407, Louisville, Ky. 40206). Looks to us like Phil missed a bet by not making up sets of two for the rodeo-rider market.







## Whatsit revealed

The thing is a serpent, an obsolete musical instrument dating from about the 14th century, made of leather-covered wood. For some reason, after going out of fashion in orchestras 100 years ago, the serpent is making something of a comeback, having been used as a featured instrument recently on some far-out movie soundtracks. Christopher Monk (with instrument) of Surrey, England, heads a small craft group building serpents, sackbuts and other Renaissance-period instruments by hand. They sell about 1000 per year.



## Mr. Welk, please call your office

Things got a little out of hand recently at the Bubble Machine Car Wash in Dublin, Calif., one of those, er, automatic facilities. One concerned mother phoned authorities to report her son had returned home spotless from an afternoon's play.

## Albatros under glass

Don Ryder, who got started flying during World War II and went into civilian stints as a forestry patrol pilot and a cropduster, now teaches math at Piedmont College in Georgia. When old salts finally hit the beach, Ryder recalled, they build ships in bottles. He further reckoned that retired blue-yonder types ought to have their own variation on that theme. He started spending his weekends building 1/72-scale plastic airplane models inside wine bottles—mostly the 1.5-liter size used for the Gallo line, if PM's eye is right—and has amassed a collection of almost the entire World War I airfleet.

Coat-hanger wire with masking tape stuck to one end is Ryder's basic tool. We didn't ask where the bottles come from, but assume the entire math class is on a Hearty Burgundy diet.



Ryder and birds-in-a-bottle collection.



Sopwith Tri-plane (left) and Luftwaffe's Albatros.



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The Fuel Pincher is built with sturdy diesel construction to be dependable and spend little time in the shop. It has no carburetor or electrical ignition system. No spark plugs. No special emissions equipment. So it should help you cut both downtime and maintenance costs compared to its gasoline counterparts.

Find out more about the economical new Fuel Pincher Diesel—including its 50,000-mile/24-month limited warranty—from your local truck dealer. Or call

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## NOTES FROM THE EDITOR

*John A. Schletter*

**T**une up your car at your desk? Or at the kitchen table?

Well... it's a slight exaggeration, but, really, the idea is not all that farfetched. With the advent of computers in all 1981 General Motors cars, and with other manufacturers adding computers to their machines, more and more internal functions of cars—metering fuel, for example—are being controlled by those magical little black boxes under the hood or behind the dash. And, as we explain on page 140 of this May's *Car Care Guide*, you can change the characteristics of your auto simply by plugging a different, programmed chip into the computer.

The assembly that contains the chip is only about one inch long. The one in your car may provide a fuel mix that gives great mileage, but not much else. Say you want to show off a bit at a rally and you want performance, not mpg. You simply pull out the first chip and plug in another. And you don't even get your hands dirty!

But enough of this, because all of us know that no matter how marvelous our gadgets become, something will break. And a tire will go flat. The car won't start in the morning. And somebody still has to wash and wax, and somebody has to replace the shocks.

So for the ninth consecutive May, we've had *Car Clinic* Editor Mort Schultz explain clearly and simply—as he does so well—how to take care of your car.

This time we're concentrating on the 50 most frequently replaced items. Mort knows better than anyone else which parts fail or need replacing most often: He gets thousands of letters every year from PM readers who experience every kind of car trouble known to man.

We're looking into these computers a bit, too, for a couple of reasons: They're here right now, and you should have some idea of what they do.

Admittedly, there may not be much that the average back-yard mechanic can fix in a malfunctioning box full of electronic gear. But much of the monitoring done by those electronic brains is of mechanical functions you *can* fix yourself.

The trick, of course, is to keep your car so well maintained that when a warning light does come on, you know that something's wrong with the light—not your car.



Auto Editor Tony Assenza tunes up his car while he sits at his desk in the office. See page 140 for a description of what that black box does in a car.



# Get out of the rat race with your own TV or audio service business.

**NRI will train you at home to service TV, audio equipment, video recorders, car stereo and more. Then show you how to run your own full- or part-time business.**

Why stay stuck in a dead-end job when you can build your own future? You can learn to be a TV, audio and video technician right at home in your spare time. Get the training you need for a new career without quitting your job or traveling to and from night school. NRI makes it happen with exciting career training in TV and audio servicing.

## **Build TV, stereo, professional instruments**

NRI training is practical training. Along with easy-to-digest theory in "bite-size" lessons, you get plenty of actual "hands-on" experience as you build our Master Course's big 25" computer-controlled color TV that lets you program a whole evening's entertainment, AM/FM solid-state stereo with speakers, transistorized volt-ohm meter, 5" triggered-sweep oscilloscope, TV color pattern generator, CMOS frequency



Start in your garage or basement and watch your business grow.



Be an audio specialist servicing home and auto stereo.

counter, and perform meaningful experiments with them and the NRI Discovery Lab.<sup>®</sup>

## **Business training as well as technical training**

Of course, NRI training gets you ready to enter this field at many levels. You can start by working for an established service company, a dealer, or a manufacturer. But you can start working for yourself, too. NRI lessons show you how to set up and run a full- or part-time business. You learn job costs and billing, even how to set up a complete accounting system. That's how complete the program is.

## **The pros select NRI training**

More than a million students later, NRI is still first choice. A national survey (summary on request) shows that more than half of practicing TV technicians have had home study training, and



Get into the booming video tape recorder market.

among them, it's NRI 3 to 1 over any other school.

You can't beat the value. All in one course you get *both* color TV and audio training, *plus* video cassette and disc systems. Send for our free catalog to see it all.

## **Free catalog...**

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Our big, 100-page catalog has all the facts. Descriptions of every course, each lesson and experiment, pictures and specifications of all the equipment you get. Send for it today, no salesman will ever bother you. If the postage-paid card has been removed, write to:



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You get all this professional equipment, build this 25" (diagonal) computer-programmed TV as you learn.



# THE PM GARAGE

## CAPSULE REPORTS ON NEW AUTO PRODUCTS

### X-car filter twister

Having trouble getting that spin-on oil filter off your GM X-car? K-D Tools now makes a simple, 79-mm end-cap wrench that uses any ½-in.-drive ratchet handle—just right to reach those snug X-car filters.

The same K-D 2771 wrench fits oil filters on many other late-model GM engines, including all 1977-81 Buicks



This new filter tool is made specifically to fit the hard-to-remove X-car oil filters.

except turbos; 1979-81 Cadillacs; 1978-81 Chevrolet Fours, nonturbo-charged V6s, and the Caprice diesel; plus Olds and Pontiac V6s.

The K-D 2771 oil-filter wrench retails for \$3.99 at major auto-parts stores.—*M.L.*

### Retractable test leads

If you've ever needed to make a jumper test lead for anything from running stereo speaker wires to checking your car's burglar alarm, Kastar's retractable 10-foot test lead is a must for your toolbox. The



Retractable 16-gauge test leads are not spring-loaded, must be rewound by hand.

tool consists of a 4½-in.-dia. plastic spool which houses a single, 10-ft. length of insulated, 18-gauge copper wire. It's long enough to run a jumper to practically anywhere on your car's electrical system. Alligator clips, with insulators, are fitted to the ends of the wire.

The Kastar retractable test lead sells for \$4.75 at most automotive parts stores. Kastar Inc. is located at Station Rd. and Sunrise Hwy., Bellport, N.Y. 11713.—*Joel Breault*

### No more drain-plug mess

If you're a driveway oil changer, here's good news—a sliding-gate valve that replaces the drain plug. Once you've installed it, you never need to mess with plugs again.

It's called a Balch Valve, and



Sliding-gate drain valve replaces the original oil drain plug for a fast oil change.

installation requires no tools. Merely screw the valve in finger-tight. It's made of Nylon 8202, which absorbs moisture, helping to hold it in the oilpan.

The Balch Valve is currently available only for Ford Motor Co., Chrysler Corp. and some GM cars. Price is \$5 postpaid. Order from Balch Valve Co. Inc., Box 2350-PM, Napa, Calif. 94558.—*M.L.*

### Invisible body guard

Nicks and chips in a car's paint allow rusting to start. TMP (Taylor Made Products), 3200 West Market, Akron, Ohio 44313, now offers a 24-oz. aerosol can of invisible vinyl spray that wards off stones and flying debris and keeps them from getting to the car's paint.

Application involves spraying the clean surface, and you don't see the vinyl once it's on. A precaution: Be sure surface is clean and there's no dust or lint in the air.



Clear spray coating prevents pebbles and road tar from getting to your car's paint.

The product is called Invisible Body Guard. It costs \$3.75 and is at most auto stores.—*M.L.*

### Magnet foils thieves

The trick to this antitheft device involves a magnet. Unless you know exactly where to place the magnet, the engine won't start.

I installed the Phantom system in my wife's 1978 Fairmont. The task took 20 minutes, with only a wire cutter and 12-v. test light needed. Cut the lead to the ignition switch, hook in two wires, and hide the mag-



Hidden burglar alarm can only be deactivated with magnet that's provided in kit.

net-sensitive pickup behind the instrument panel. The pickup fits anywhere; the magnet works through nonmetallic surfaces ¼ in. thick.

The Phantom costs \$49.95, plus \$1.50 shipping from Falls Enterprises Inc., 17096 Chillicothe Rd., Chagrin Falls, Ohio 44022.—*M.L.*



# INTRODUCING CHEVY LUV. NEWEST EVER. TOUGH AS EVER.

**SLICK TO CUT AIR DRAG.** One look will tell you it's a different Chevy LUV: sleeker, sportier, with smoother lines.

**36 26** **THRIFTIEST LUV EVER.**  
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All that new style and aerodynamics have paid off handsomely with LUV's best mileage estimates ever!

**EFFICIENT 4WD.**  
LUV 4WD has the best standard-equipped 4x4 pickup mileage estimates in the U.S.A.!  
**31 22**  
EST. HWY. EPA EST. MPG (CITY)  
Use estimated MPG for comparisons. Your mileage may differ depending on

speed, distance, weather. Mileage will be less in heavy city traffic. Actual highway mileage lower. Lower in California, where comparisons do not apply.

*A Word About Engines:* Chevy LUV engines are produced by Isuzu Motors Limited, Japan.

## NEW ROOM TO RELAX.

LUV's easier to get into and out of this year. Once you're inside you can enjoy the improved leg room, the rich new upholstery and trim, not to mention the new instrument panel and the new side window defoggers.

## LONGEST BOX OF ANY SMALL PICKUP.

LUV's a hard worker, too. 2WD available with the longest cargo box in its class (7½ ft.!) And it'll hold more payload than any small half-tonner: 1680 lbs. including driver, passenger, equipment and cargo! See the all-new Chevy LUV at your Chevy dealer's, soon.



CHEVY LUV 4WD



CHEVY LUV 2WD



**BUILT TOUGH.  
BUILT FOR ECONOMY.**





## PM builds the first video camera kit

Building a TV camera isn't as hard as it seems. This new kit lets the advanced project builder tackle the latest in video technology.

by Neil Shapiro  
ELECTRONICS EDITOR

**T**he temptation was to shout, "Lights, camera, action!" but I restrained myself as I set up a video camera for its first off-the-bench test. It hooked directly to the television antenna terminals. Focusing took a few seconds, then I was watching a TV picture taken under normal room lighting conditions. The black-and-white image was crisp and clear.

It was a real feeling of accomplishment, because the camera had been built from a kit. It was the ATV Research Series "D" camera (\$185 from ATV Research, Dakota City, [\(Please turn to page 24\)](#)



Photo of actual picture taken with the Series "D" camera (top) shows crisp image. Three main controls on back of camera (above) let you adjust for just about any level of normal room light. Controls do interact, so it will take time to get used to the adjusting. A switch sends pictures to a monitor (video) or to an unmodified television (RF).



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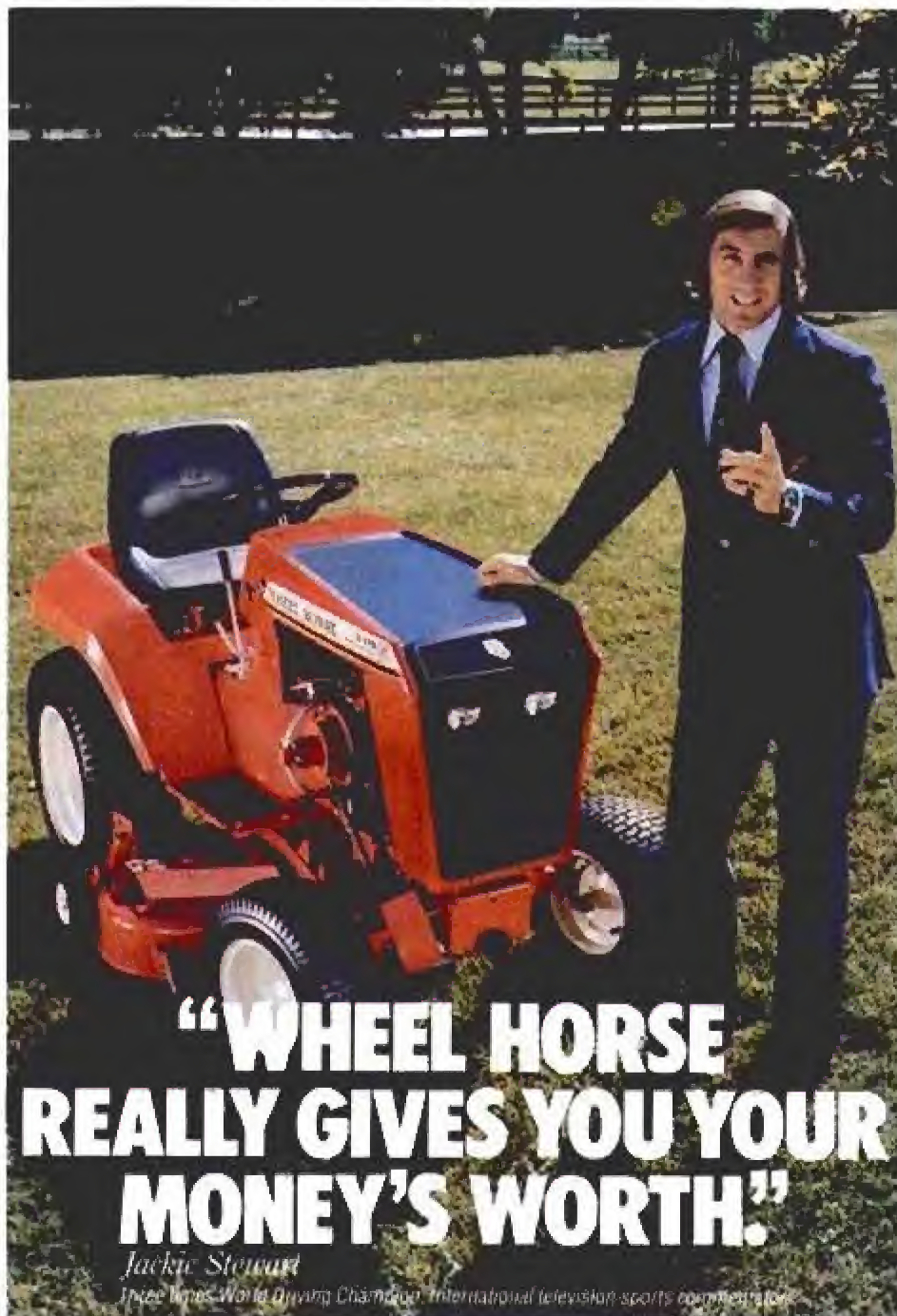
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**"DON'T BUY A LAWN AND  
GARDEN TRACTOR, INVEST IN ONE."**



## Wheel Horse.

515 West Ireland Road • South Bend, IN 46614

## PM BUILDS VIDEO CAMERA KIT

(Continued from page 22)

Nev. 68731), and it had only taken a few evenings to build.

We thought twice before tackling this project—the instructions were complete and straightforward, but two unusual features make this a kit for advanced builders. The cabinet and printed-circuit board are not predrilled. The board was easy to do with a small drill, but the cabinet presented problems as we had no real metalworking tools. The coil assembly around the vidicon tube (video lens) also involved critical



Circuit construction is easy and open. It gets cramped only around the vidicon tube.

work. But if you have built complex kits before, don't be scared off by this one.

### Around the home

Finished, the camera hooks up to either an unmodified TV or a video monitor. We used a TV along with a videotape recorder for some home movies (or perhaps we should say "tapes"). In the ham shack, we used the camera along with a Robot 400 (see *Now Ham Operators Have Got the Picture*, page 122, Mar. '80) to send slow-scan TV.

The camera worked well, though we found it more difficult to use than the average ready-made video camera. The focusing is a bit harder and more critical. Three controls on the back all interact to "tune in" the final picture. But, with practice, we found ourselves tuning the ATV Series "D" with ease.

This camera would be perfect for the homeowner who wants to set up a closed-circuit TV system for security. You need no expensive RF monitor. A switch lets you choose the RF position and send the signals through the antenna terminals of any TV set.

We also found no special room lighting was needed in most situations. The sensitive vidicon can deliver a good image in normal lighting. (You'll want to avoid such errors as harsh backlighting, but it shouldn't take long before you feel aware of the camera's abilities.)

If you are thinking of buying a TV camera, and you like a challenge, audition a Series "D."

PM



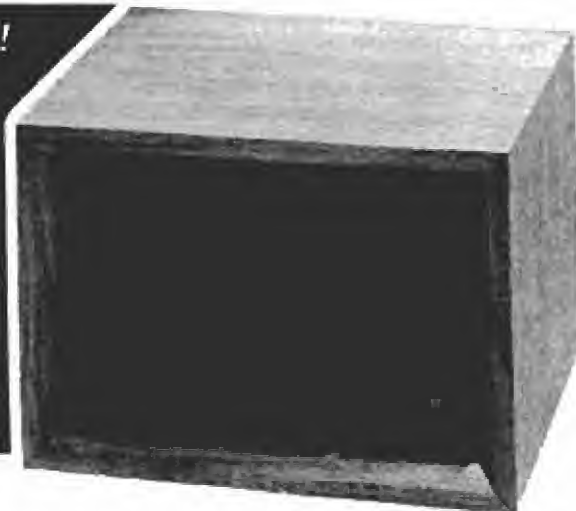
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**Turns On Lights Automatically**

**Powerful Electronic Siren**



## Low Cost Computerized Burglar Alarm System Home - Office - Business

### NO INSTALLATION

Just plug the Guardex 8000 alarm system in, make two simple control adjustments to suit your particular building and it works! There are no other wires to run. This totally self-contained burglar alarm can completely seal off every square inch of the surface of your building. It protects doors, windows, and what most alarms miss... your roof, walls and floors.

### HOW CAN ONE SMALL COMPUTER PROTECT MY WHOLE BUILDING?

Guardex 8000 Alarm System works on the principle of audio discrimination. This, put simply, is the process of electronically separating normal everyday sounds, such as voices, telephones, etc. from break-in type noises such as breaking glass, prying metal, or forcing a door open. The Guardex 8000 protects one story homes and offices up to 2000 square feet and open commercial buildings up to 10,000 square feet. The Guardex 9300 with wireless remote sensor capability is available for multi-story homes and offices or single story with more than 2000 square feet. Call the factory for more detailed information.

### TURNS ON LIGHTS AUTOMATICALLY

When the first break-in type sound is detected, the system will instantly turn on lights, radio, or other electronic equipment that you have plugged into the back of the alarm. These lights or other equipment will remain on for a period of five minutes, then automatically turn off.

### POWERFUL ELECTRONIC SIREN

The Guardex 8000 alarm is equipped with a loud built-in siren. If during the five minute period the lights or other electronic equipment has been activated, a second break-in sound is detected, (it can be only a second or two after the first break-in sound) the built-in siren will start blasting for 90 seconds. At the end of approximately 90 seconds the siren will shut off and the alarm listens again. If another break-in sound is heard, the siren will come on for another 90 seconds. If no other break-in sound is detected, the siren will stay off and at the end of the five minute period the lights will shut off and the alarm instantly resets.



The rear control panel contains two standard AC plug receptacles for a table lamp, spot lights, radio, etc., terminals for connecting optional outside siren and back-up battery (not included); entry delay time control and sensitivity control.

The Guardex 8000 Alarm System is walnut grained and disguised to look like a small stereo speaker (6 1/4" x 9 1/4" x 8") and weighs less than 6 1/2 pounds.

### EXIT AND ENTRY DELAY

The Guardex 8000 alarm has a built-in exit delay allowing you approximately one minute to lock up and leave the building before the alarm is armed. When you enter your building you may find that just your normal entering sounds activate the siren. You may delay it from starting for up to 30 seconds by turning up the siren entry delay control.

### BATTERY BACK-UP

Burglars rarely cut power. However, to give you total protection from a burglar and possible power failure, our alarm has provisions for a battery back-up. (Batteries not included). 12 volt lantern batteries are available at most hardware stores.

### THE BURGLARY PROBLEM

The F.B.I. statistics show that at the present rate, one out of every four Americans are going to be burglarized. That is not a very pleasant fact, but it is true. You have a greater chance of being burglarized than being a victim of a fire or automobile accident. The time is now to help protect yourself and your valuables with a Guardex 8000 alarm system.

### OUTSIDE SIREN

The Guardex 8000 alarm is equipped with a loud, built-in siren, but if you desire an additional siren to mount outside or in an area away from the main alarm, they are available with 50 feet of wire for \$24.95. (Connecting terminals are provided on the back of the alarm).

### 30 DAY NO RISK TRIAL

This is your opportunity to purchase an alarm system directly from the factory for only \$199.95. Try it in your home or business for thirty days without risking one cent. Put our Guardex 8000 alarm to your own test. See for yourself! It will protect every window and door from break-in. If you are not completely satisfied, return the alarm within 30 days for a complete refund. To order your Guardex 8000 alarm, CALL TOLL FREE to charge your credit card or send your check to Guardian Electronics, Inc. in the amount of \$199.95 plus \$3.50 postage and handling. If you want the optional outside siren, add \$24.95 (California residents add 6% sales tax.)

(If you require more information, call during California business hours, Monday - Friday).

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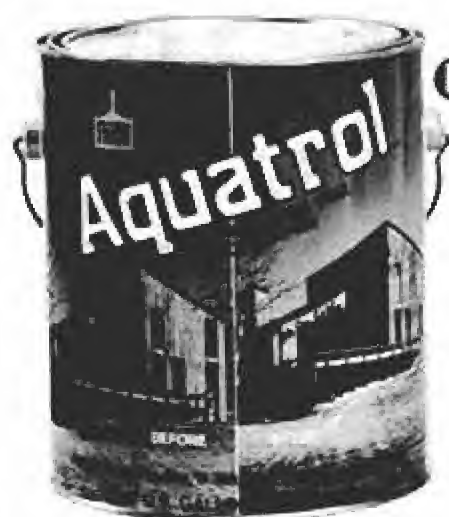
# NEW NOW for home and shop



**A** Several Mighty Oak kitchen knives and matching steak knives are now available in a pair of solid oak racks designed to conserve counter space. The larger rack comes with 8-in. French chef knife, 6-in. boner and 3½-in. parer. It sells for \$75. The other, with six steak knives, sells for \$70. All handles are oak and the blades are hand-honed, stain-resistant, high-carbon steel. Racks and knives must be purchased together and are available at large department stores. Made by Imperial Knives, 1776 Broadway, New York, N.Y. 10019.

**B** Aquatrol is a new, clear wood finish designed for exterior use. According to the maker it won't crack or peel, it's mildew-resistant and it can bring back the original wood tone to a slightly weathered siding. It's available in quart, gallon and 5-gallon sizes for \$6.09, \$18.25 and \$89.45, respectively. It covers 100 to 125 sq. ft. per gallon and the manufacturer claims it will maintain the same color

on the siding for two years. Brushes come clean in soap and water. The product can be found in paint stores and home centers. Made by the Flood Co., 1213 Barlow Rd., Hudson, Ohio 44236.



**C** PlankSide is a new prefinished hardboard siding from Masonite that comes with a grooved and textured surface to simulate random-width and random-length planking. The product is available in red or gray and carries a five-year prefinish warranty. A 4×8-ft. sheet costs about \$23, the 4×9-ft. sheet is \$25. Both are ¾ in. thick and have shiplap edges. The maker also supplies color-coated nails, plus matching stain and caulk. Currently, the product is available only in the Midwest, South and Southeast at lumberyards and home centers. To find out if it's in your area, write Masonite Corp., 29 North Wacker Dr., Chicago, Ill. 60606.

**D** The Imperial Marble design has been introduced recently into Armstrong's Stylistik line of do-it-yourself self-stick vinyl tile. Offered in white, blue or natural shades with a slightly textured surface, the tile is easy to clean, stain-resistant, and will adhere to any clean, dry surface. The tiles are shipped 45 to the box and, depending on the individual retailer, may be sold separately or only by the box. The cost is \$40.50 per box, or 90 cents per 12-in. square tile; at Armstrong tile distributors. For further information write to Armstrong World Industries Inc., Box 3001, Lancaster, Pa. 17604.

PM







# Johnson dependable V-power and performance ...from the people who wrote the book.

Big boats. Big water. That's what Johnson® V-4 and V-6 outboard power is all about. So if you need 90 to 235 hp, look to the source...the people who brought V-block engineering to the world of outboarding way back in 1958.



## Let's compare apples with apples.

We've learned a lot about outboard power over the years and lead the way in V engineering. Now some competitors are manufacturing Vs ...60-degree Vs compared to our 90-degree design. We think they've missed the boat.

The 90-degree V gives our engineers several advantages. Like more room between cylinder banks to design more efficient intake and exhaust systems. More room for better

cylinder cooling. And an engine that's inherently better balanced and smoother.

## And that's just for openers.

Our dual MagFlash® electronic ignition system assures quick starts, smooth idling and consistent running at all speeds. And unlike systems which use distributors, MagFlash has no moving parts to replace... never needs adjustments.

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Fuel economy starts with our Top-Charge™ carburetor system that supplies a constant fuel/air mixture regardless of the motor's trim position for quicker, cleaner starts and improved low speed running. Exhaust tuning

keeps the fuel charge cleaner for more efficient combustion and greater power on less fuel. Fact is, over the years we have been constantly refining and improving our line-up of V-4 and V-6 motors. Today, for example, we can look back 20 years and know that our new V-4s are at least 50% more fuel efficient than those that revolutionized the industry. No wonder the world runs more Johnsons than any other outboard.

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## HINTS FROM READERS

### Garbage-bag holder



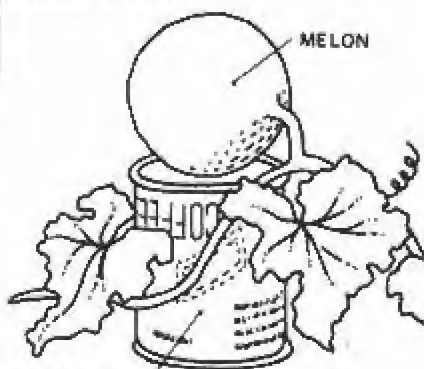
Make a portable garbage-bag holder from a wooden pants hanger. Bore and attach a screw at all hanger ends.



Permanently attach the holder to a wall or hang wherever it is convenient.

To make a garbage-bag holder, turn two roundhead woodscrews, 1/4-in. longer than wood thickness, through a wooden hanger bar. Bore aligning oversize holes in the second bar, hang bag on screws, close hanger.—A. Nosich

### Canned melon



INVERTED COFFEE CAN

The National Assn. for Gardening suggests placing your growing melons on inverted coffee cans. They'll get more light and ripen more evenly when elevated.

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Record telephone conversations in your office or home. Connects between any cassette or tape recorder and your telephone or telephone LINE. Starts automatically when phone is answered. Records both sides of phone conversation. Stops recorder when phone is hung up. This device is not an answering service.

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Call (305) 725-1000 or send \$18.95 + \$1.00 shipping per item to USI Corp., P.O. Box PM-2052, Melbourne, FL 32901. C.O.D.'s accepted. For catalog of transmitters, voice scramblers and other specialty items, enclose \$2.00 to USI Corp.

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# PHOTO HINTS

## A reel adjustment



You probably use adjustable developing reels that accommodate various film sizes. Problems arise if halfway through the process, the setting slips. To prevent this, fit the core with a spacer of stiff plastic. Here, we use an old radio coil form.—*Robert Hertzberg*

## Inexpensive tacking



Dry-mounting irons are often used to tack tissue and photo to a mounting board. But such irons are expensive if you don't do much mounting. An electric soldering gun (with a well-cleaned or new flat tip) provides quick heat in little time.—*A. Weber*

## Flash cord fix



If you've ever tried to take a picture and pressed the shutter only to note your flash cord was disconnected, take note. Tie the flash cord around a strap ring so it won't pull out.—*Bob Berger*

# Geocel runs rings around crumbly caulks.



Geocel Caulking Sealant lasts so long you may never have to caulk again. It's a unique elastomeric copolymer that penetrates into cracks to seal out water and weather like no ordinary caulk can.

Geocel adheres to virtually any building material. It stays pliable for years and forms a watertight bond that actually improves with time. It's twice as stretchable as silicone sealants, yet costs less.

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# IMPORTS & MOTORSPORTS

## Back on the track



Ford Mustang prepared by Autodyne will run in IMSA road-racing series.

The Ford Motor Co. is going racing—again. The first auto race for Ford—Henry, that is—was just 80 years ago. He took the wheel of his first racing car and beat Alexander Winton, the Cleveland automaker. Winning with his hand-built Ford racer impressed the public and earned Henry the support and money he needed to found his very own car company. Once there were factories, factory support couldn't be far behind, and Ford Motor Co. has supported motorsports in all its forms. Most recently, who can forget the glory days of the late '60s when Ford had machines and motors at Indy.



Lyn St. James will race in car No. 62.

on NASCAR ovals and in the victory lane at LeMans? This time around, though, Ford isn't out to conquer the world. In its first trip back to the track since 1970, the auto company, through its newly formed Special Vehicles Operations (SVO), will be backing Mustang entries in three road-racing series. For the International Motor Sports Assn. (IMSA) GT series, Bill Scott will prepare a 1.7-liter turbo Mus-

tang that Klaus Ludwig will drive. A 302 V8 will be fielded in the Sports Car Club of America (SCCA) Trans-Am Championship with Dennis Mecham at the wheel. Ford will enter another 302 in the IMSA Kelly American Challenge. It'll be set up by Autodyne and be driven by the president of that Ft. Lauderdale-based auto parts supplier. She is Lyn St. James, a tigress on the track, but a gentlewoman and articulate speaker: She'll be touting Ford performance where the real tough competition takes place—in the showrooms. You should know, men, Ford has its eyes on your wives and daughters. Women buy a lot of cars and Ford Motor Co. is out courting. You can't lock up the ladies anymore, so see that they're as knowledgeable about cars as you are: Share your issues of PM.

## Blast from the past

The racers were shipped to North America from England in the early '50s and began roaring around road



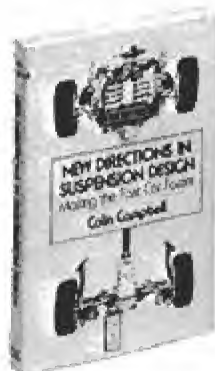
Allard J2X2 is the latest cloned classic.

circuits from Bridgehampton to Pebble Beach. To a kid who was just starting to maneuver a huge, gray, '51 Pontiac up and down a narrow driveway, trying not to hit the fence, Allards were among the most exciting cars in the world. Founder Sydney Allard died in 1966 and the marque became defunct. Recently, however, two old Allard fans in Canada formed the Allard Motor Company Ltd. and they are making J2X2s at 5309 Maingate Dr., Mississauga, Ont. L4W 1G6.

## Hold the road

Most car buffs or motorheads, as they sometimes call themselves, begin their hobby or career infatuated with engines. Of course, there's a whole lot more to driving than just getting from 0 to 60 mph swiftly and smoothly. If you want to better

understand how a suspension that holds the road makes a car run faster, try reading Colin Campbell's *New Directions in Suspension Design*. It's got a little high-school math and is good, solid, easy-to-digest book learnin'. It's \$14.95 from Robert Bentley Inc., 872 Massachusetts Ave., Cambridge, Mass. 02139.



Suspension savvy is in this new book.

## Car quiz

If you saw the headlight in last month's I&M (page 87) and identified the car as a New York taxi, you were right. Well, partially. The car is



Peugeot 505 turbodiesel in metallic blue.

a Peugeot 505 and, yes, the diesel version is being used in taxi fleets. The model we drove recently is the new turbodiesel and it's one of the smoothest and most luxurious automobiles around. It's also one of the best looking—as long as it's not yellow. Imagine, a cab designed by Pininfarina.

PM

## 1981 IMSA and SCCA events

April 12, Gainesville, Ga. (IMSA); 26, Riverside, Calif. (IMSA); May 3, Laguna Seca, Calif. (IMSA); 26, Lime Rock, Conn. (IMSA); 31, Lexington, Ohio (IMSA); Sonoma, Calif. (SCCA); June 14, Brainerd, Minn. (IMSA); Portland, Ore. (SCCA); 21, St. Pie, Que. (IMSA); July 3-4, Daytona Beach, Fla. (IMSA); 12, Watkins Glen, N.Y. (IMSA); 14, Lime Rock, Conn. (SCCA); 26, Sonoma, Calif. (IMSA); Elkhart Lake, Wis. (SCCA); August 2, Portland, Ore. (IMSA); 9, Brainerd, Minn. (SCCA); 15-16, Bowmanville, Ont. (IMSA); 22-23, Elkhart Lake, Wis. (IMSA); Watkins Glen, N.Y. (SCCA); 30, Lexington, Ohio (IMSA); September 5, Trois-Rivieres, Que. (SCCA); 20, Gainesville, Ga. (IMSA); October 18, Laguna Seca, Calif. (SCCA); 25, Riverside, Calif. (SCCA); November 29, Daytona Beach, Fla. (IMSA).

BY BILL HARTFORD





# LONG DISTANCE HAULER. NEW DATSUN DIESEL



## WHAT'S THE LONGEST DISTANCE BETWEEN TWO PUMPS? FOR DATSUN PICKUPS, IT'S OVER 550 MILES:

Introducing the new Datsun diesel. It has the power and mileage you'd expect in a diesel, and in the Long Bed more range than any Datsun ever: 557\* miles on a tankful, from an engine with over 3 billion miles of experience behind it. Datsun and diesel: a tough combination.

### A TRUE TRUCK.

This rugged rig is a half-ton of tough, suspended in front on ride-smoothing independent front torsion bars. It hauls a full 1,400-pound payload of cargo and passengers on a ladder-type chassis. Just like a semi.

## THREE TOUGH CHOICES.

Choose from the Long Bed, exclusive King Cab® or the Li'l Hustler™...biggest choice in compact diesel pickups. Whichever Datsun diesel you pick, you're getting the greatest economy of all: miles per gallon and years per pickup. Just what you'd expect from Nissan Motor Co. Ltd., the worldwide company whose name stands for quality.

Want to go more miles between fill-ups? Go straight to your Datsun truck stop.

|                     |                         |
|---------------------|-------------------------|
| <b>557</b>          | <b>692</b>              |
| MILES<br>EST. RANGE | MILES<br>EST. HWY RANGE |
| <b>33</b>           | <b>41</b>               |
| EPA EST. MPG        | EPA EST. HWY            |

Range estimates based on EPA est. mpg and hwy mpg multiplied by 16.9 gal. tank. Use est. mpg for comparison; your mileage may differ depending on speed, trip length and weather. Hwy mileage and range will probably be lower. Not available in California.



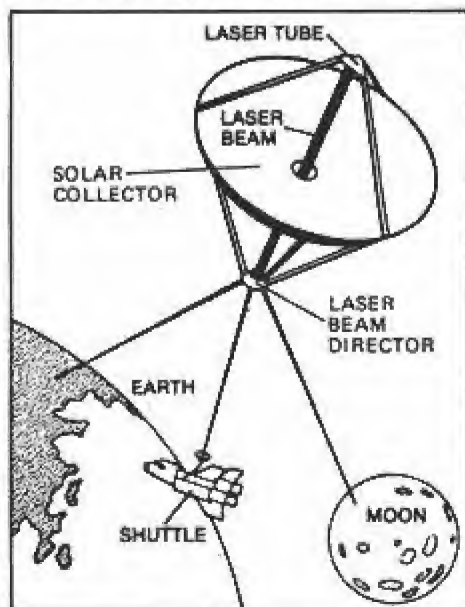


# SCIENCE WORLDWIDE

## Solar-powered laser

The device illustrated here snares sunlight in space and focuses it on a gas-containing laser tube which fires bursts of energy-packed laser beams.

Researchers at the National Aeronautics and Space Administration (NASA) recently built a working prototype of the sun-powered gas laser. Its main advantage is simplicity: Sun excites the gas without first being converted (at low efficiency) to electricity to power the laser.



Sun-excited gas tube emits a laser beam.

Lofted into space, solar lasers could help supply the space shuttle with power, or they could be used to beam energy to the Earth or the moon.

## Medical clues in masterworks

Some paintings by the 17th-century artist Peter Paul Rubens contain clues that may help doctors today understand the origin of rheumatoid arthritis.

The disease, characterized by pain and swelling of joints, has a puzzling history. Doctors haven't been able to find case histories earlier than about 1800. Shakespeare, who chronicled many diseases through his characters, was silent about the swollen knuckles and ridges on the wrist familiar to modern arthritis specialists.

But now, evidence that the disease existed in Rubens's—and Shakespeare's—time comes from a group of Belgian and American doctors, who found clues in huge canvases on display in Antwerp. "One of

us said, 'Isn't that a rheumatoid hand?'" says Dr. George E. Ehrlich of Philadelphia. And other specialists concurred in the diagnosis after examining the 300-year-old painting.

When they examined other Rubens works completed later in his life, they discovered more advanced symptoms. Theory: Rubens used models for faces, but he used his own arthritic hands as standards to complete his paintings. Further speculation: Perhaps the origin of rheumatoid arthritis is related to the growth of cities in the 1600s. Support for this hypothesis comes from modern research in South Africa. Ehrlich tells us, where more city residents suffer rheumatoid arthritis than people in the country. Why? "No one knows," Ehrlich says.

## Dodging spring ozone

Airlines have their hands full keeping an obnoxious intruder—ozone—out of their passenger cabins this time of year.

The unstable, pale-blue stratospheric gas absorbs the sun's harmful ultraviolet radiation. But when it seeps into airliners, it can cause watery eyes, chest pains, throat irritation and coughing. The problem can be acute in the spring, when the ozone layer descends in patches as low as 25,000 feet.

But this spring, airlines are fighting back, with the help of a NASA satellite, the Nimbus 7. It monitors ozone by measuring ultraviolet radiation reflected by the atmosphere. For the past two months, NASA and Northwest Airlines have been joined in an experiment to see if the Nimbus can flash warnings of ozone patches so that pilots on domestic flights can skirt them. The option to this warning system is not attractive: An on-board device to convert ozone into oxygen costs about \$30,000.

## X-ray microscopes

IBM Corp. scientists foresee a new generation of X-ray microscopes that should be able to monitor the movement of atoms in a nerve cell that's poised to fire, or examine the structure of coils of molecules locking in data about human heredity.

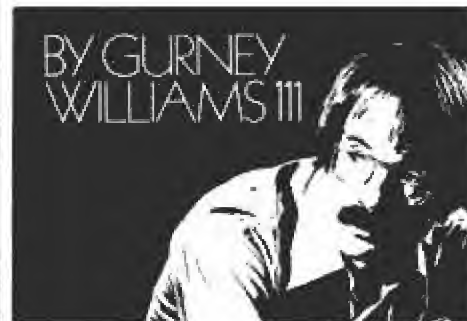
Key elements in these microscopes are IBM-designed mirrors which focus powerful beams of X-rays from synchrotrons—rings that accelerate subatomic particles to

high speeds. The surface of these mirrors is a Dagwood sandwich made of hundreds of layers of carbon, an alloy of rhenium and tungsten and other materials. Used in a microscope, such a mirror would focus an X-ray beam through a biological sample. Slight changes in the wavelength of the X-ray could be used to display specific substances such as calcium ions in a nerve cell that is about to fire. The "shadow" of the lab specimen passes on to a receiver and amplifier.



Mirrors are made in high-vacuum chamber.

The IBM work should provide another option to the scanning electron microscope (SEM), which uses beams of charged electrons focused electromagnetically. SEM techniques require extensive sample preparation that can distort biological specimens. The radiation from an X-ray scope may kill sample cells, but they should remain viable long enough to reveal more about the nature of life. **PM**







# Best catches of the season from Shakespeare.

No matter what kind of fishing you plan to do this season, Shakespeare's got an Alpha™ rod-and-reel combination that's bound to catch your fancy. At a price that won't leave you cold,

Like our Alpha bait-casting combination. For under \$60, you get one of America's lightest, smoothest-working all-metal reels. It sports a high-speed retrieve and a drag system with over 200% more drag surface than other reels. Match it up with a strong, one-piece Alpha bait-casting rod, and you've got one of the most fishable combinations on the water.

For spin-cast fishermen, there's our rugged Alpha spin-cast

combination. An all-metal reel featuring fast, sure retrieves, a star drag mechanism that eliminates line twists, and a line-gobbling gear ratio. Tighten it down on a tough Alpha rod and you can go fishin' for less than \$25.

For less than \$35, there's our Alpha spinning combination. You get an Alpha 040 reel that features ball-bearing action. Selective Internal Trip™, a high-speed gear ratio, and a convertible handle for left- or right-hand retrieve. Plus a two-piece, ferrule-less Alpha rod that combines tough tubular construction with continuous butt-to-tip sensitivity.

All of which means that, for the price of somebody else's cheap rod-and-reel combination, you can hook into one of the best catches of the season.

An Alpha rod-and-reel combination from Shakespeare.

**Shakespeare®** **alpha™**

America goes fishin' with Shakespeare



# ALL OUTDOORS

## What's best?

Every year, a guessing game takes place when manufacturers and dealers of recreational gear gather for a look at the latest in equipment. It's called the National Sporting Goods Assn.'s annual convention and show. This is where sports shop owners have to bet their money on what we will come looking for the rest of the year. Will it be tennis, jogging, camping or fishing gear? Or will we stay home for back-yard barbecues, or venture inside for billiards, darts and bowling?

Some sports—hunting, fishing, boating, tenting, tennis, golf and skiing—will continue to be big, according to estimates at the recent show. But with prices for equipment continuing to rise, the fastest growing fads are the ones that offer new fun for the money.

One is physical fitness. Equipment that once was found only in a well-equipped gym is now showing up at home. Weights, pulleys, flexing machines and exercise bikes are now available from so many suppliers that it's obvious the market is booming. And to keep an amateur body builder interested during potentially boring workouts, there are pulse recorders, expended-calorie calculators, metabolism stress testers and even the stereo-headphone radios that joggers favor for on-the-run entertainment. Pastimes that work both inside and outdoors appear to be a cost-saving way to stay in shape without leaving home.

Racquetball and tennis show some decline in equipment sales, but soccer and softball are booming. It's estimated that over a million North American youngsters and adults play soccer. Up to 30 million is the guess for the total number of amateur softball players in the United States. About 80 percent play "slow-pitch" softball and there are rumors that it will be the next sport added to the Olympics. Equipment is inexpensive, with a trend to aluminum bats in a variety of sizes and weights below the 34-inch, 38-ounce official limits. Some of the slow-pitch growth comes from women, who find it an appealing sport.

Swimming, known as the "perfect" exercise, is increasing its popularity as an indoor/outdoor sport. Once you've found a place to dive in, equipment requirements are minimal.

Space-age materials are improv-

ing everything from fishing rods and golf clubs to inflatable boats, guns and backpacks. Graphite, boron, magnesium, Kevlar, Cordura, Gore-tex and Royalex are among the exotica used to make longer wearing, stronger, lighter gear.

## New tricks for TV

Now that home television sets have been taught to play assorted games with add-on gadgets, Wesmar Marine Electronics, 801 Dexter Ave. N., Seattle, Wash., 98109 has come up with an exceptional bonus for boatmen. Smaller than a breadbox (only 3 inches high, 14 inches wide) and less expensive than most radars on the market (\$2,490), this unit can display activity up to an 80-mile radius on the screen of any TV set you bring



Omnicolor can bring radar to any TV set.

on board. Wesmar calls it the Omnicolor SR1000. Offshore sailors are likely to call it one of the neatest devices they've seen.

First unveiled at the Miami International Boat Show last February, the digital color radar doesn't require a cathode-ray-tube screen of its own. If you want a big picture, just hook up a large TV set. Want to check on the helmsman while below in the galley, cabin or head? Install extra sets in any location; they can all be hooked up to one SR1000. And after you're satisfied that you're on course and no threatening rocks or craft are ahead, you can switch back to watch *Love Boat* on the same black-and-white or color TV.

With a color set, the radar picture can be adjusted for bright tones that give the best visibility for day or night use. A built-in computer provides a memory display that keeps a constant picture, rather than allow-

ing fading between sweeps of the antenna rotor. Scanner rotors are 2½ to 6½ feet wide. The popular 3-foot size, at 21 pounds, is the lightest on the market. Options include a video marker pen that triggers a digital readout of distance and bearing when it's touched to any object on the screen. Standard for the Omnicolor is an intrusion alarm that sounds a warning over your set's speaker when any target approaches closer than a preset distance.

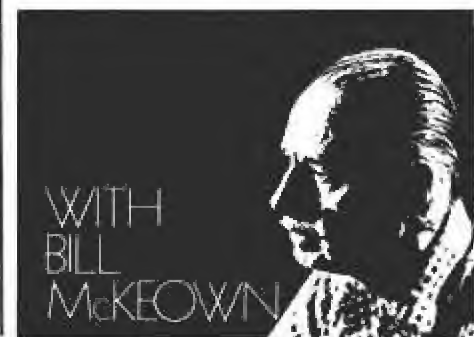
While radar is important for avoiding night-time or reduced visibility collisions, many boatmen use radar principally for navigating landfalls, running along coastlines or entering harbors. With this unit, like others, you can ease your way along a narrow channel or up a winding river. And with the Omnicolor, you can also videotape the passage and play it back later.

## Collectors' items

For knife owners and shoppers alike, a new \$5.95 volume from DBI Books, 1 Northfield Plaza, Northfield, Ill. 60093, is available. *Knives '81* covers 1,700 sources of knives and information, 400 custom makers and 1,200 retailers, plus articles on knife making, selecting and collecting. Remington's 1981 *Sporting Arms and Ammunition* catalog charts the selection of guns and cartridges for each specific use, with information on just which calibers and bullet diameters can be used interchangeably. It's free at gun dealers or from Remington Arms, Bridgeport, Conn. 06602.

## Notable dates

May 11 to 17 is National Fishing Week this year and May 29 to 31 is Sea Heritage Weekend. The weekend will be observed with a sea music festival, dory races and an annual fish fry at the Mystic Seaport Museum, Mystic, Conn. **PM**





# "AFTER 2700 MILES, MY MARINER WAS ABOUT THE ONLY THING IN ONE PIECE."

Ken Heskestad, tankerman, New City, New York



It was mid-June when Ken Heskestad left the Seaweed Yacht Club in Stony Point, New York, to begin his odyssey in a little 12-foot Avon inflatable boat, powered by a Mariner 25 hp outboard.

Twenty-seven hundred bone-jarring miles, 23 locks, 2 punctures and 3 months later, Ken motored "Inflation 1" back up the Hudson River toward home.

Total maintenance for the trip: 3 spark plugs and a new prop to replace one that was destroyed when he ran aground in a fog. Ken says, "Someday, I'd like to retrace the old Viking route back to Bergen, Norway. Whatever it is, the outboard will be a Mariner."

Mariner outboards earned a reputation for outstanding performance on 4 continents before they ever came to North America. And as more of them are getting around, so are stories



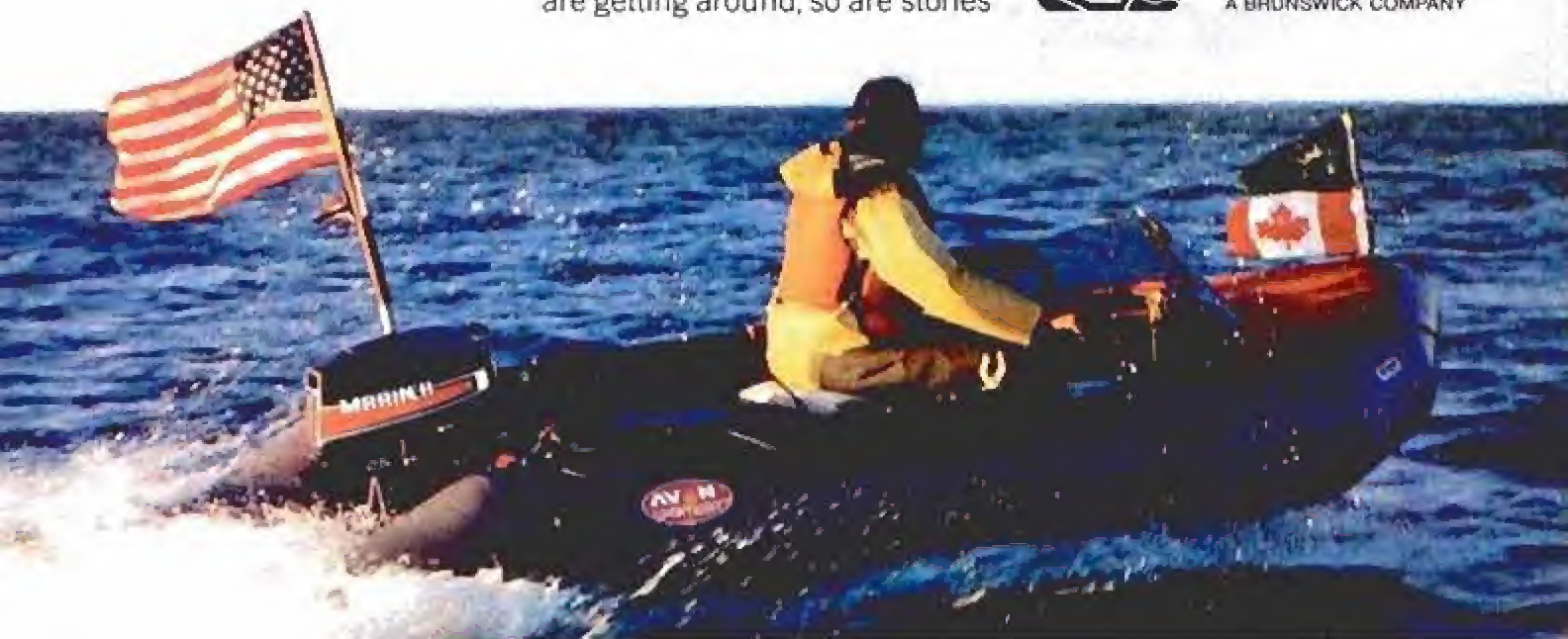
like this one. These remarkable outboards from 2 to 200 hp are proving they really are better in the long run.

For a catalog write Mariner, Dept. PM5, 1939 Pioneer Road, Fond du Lac, WI 54935. Or call toll-free 800-558-9758. In Canada, write Mariner, 1156 Dundas Hwy., East Mississauga, Ontario L4Y 2C2.

## MARINER. BETTER IN THE LONG RUN.



**MARINER<sup>®</sup>**  
**OUTBOARDS**  
A BRUNSWICK COMPANY





# DETROIT LISTENING POST

## J- and A-cars in the wings

GM's J-cars—subcompacts with the interior room of a compact—are lined up in the wings, awaiting their cue to dance on stage. They feature a conventional pushrod, 1.8-liter, four-cylinder engine that generates an impressive 85 hp at 5,100 rpm, a



Chevy's new A-car will be called Celebrity.



Pontiac's J-car will be called J-2000.

long 101-inch wheelbase for comfortable ride and rear-seat accessibility, standard power brakes, side-window defoggers and reclining front bucket seats. They also have a unique semi-independent rear suspension with conical, variable-rate springs. Chevy will call its J-car Cavalier; Pontiac, J-2000 and Cadillac, Cimarron. Look for the full story on these important new entries next month.

Hoping to attain better overall quality, General Motors has delayed introduction of its '82 Camaro/Firebird sporty coupes and front-wheel-drive (fwd) intermediate A-cars by two months, to November of this year.

The sport coupes shrink in overall size, but retain their current interior room, rear-wheel drive and, above all, sexy looks and exciting personalities. Engine choices will range from a 2.5-liter Four to a fuel-injected 5.0-liter V8. The A-cars, spinoffs from the successful compact X-cars, will replace the Chevy Malibu, Pontiac LeMans, Olds Cutlass and Buick Century, and will also feature standard four-cylinder and optional V6 engines.

Pontiac drops its full-size Catalina and Bonneville this fall, but a new mid-size four-door on the rear-drive Grand Prix platform will inherit the

Bonneville name and position in the family-car pecking order. In keeping with the European image the division is seeking, its new fwd mid-size car will be called A-6000 and the compact (X-car) Phoenix may become X-3000.

Chevrolet will keep its full-size Impala and Caprice for now, as well as the mid-size Malibu wagon, but the rest of its Malibu (A-car) line yields to the new X-based front-drivers. Tentative name for these is Celebrity. Sounds positively Japanese.

Delayed even more are the fwd full-size (B-car) and intermediate specialty (A-special) programs slated for '83 and '84, respectively. The former replaces GM's rear-drive large cars ranging from Chevy Impala to Cadillac deVille; the latter retires the current Monte Carlo, Grand Prix, Cutlass Supreme and Regal personal coupes—but not until six months later than originally planned. Also shoved back half a year are downsized and redesigned '84 (now '84½) E-car (Seville) luxury models.

## Ford future models

Ford is still scrambling its future-product plans in response to coming market demands, what GM and others are planning and, of course, how much money is available for new-product investments.

Right now, it looks as if the current full-size Ford LTD and Mercury Marquis will get the ax after '83 and won't be replaced. But their final year will be the first for an all new downsized Thunderbird/Cougar ('83) and a fwd Fairmont/Zephyr replacement ('83½) based on a stretched Escort/Lynx platform. New this year, the Granada/Cougar four-doors will shrink and go fwd about mid-'85. The sporty Mustang and Cougar get restyled for '83 and again three years later, but will keep their current size and rear-drive configuration.

Along about '86 will come an all-new series of fiberglass-bodied micro-mini commuter cars to compete with GM's '83 P-car and '84 S-car two-seaters.

Once General Motors has tested and proven the tiny-car market, Ford hopes to move in with 1,300 to 1,500-pound micros in the 73 to 85-inch-wheelbase range. They'll offer

choices of two- or four-passenger capacity, three- or four-cylinder engines (gas or diesel) and five-speed manual or four-speed automatic overdrive transmission. Fuel economy target: 50-60 mpg city.

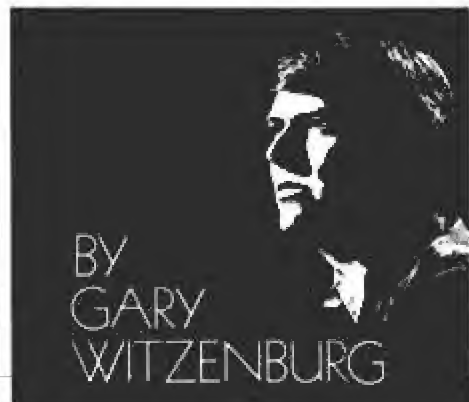
## Chrysler for '82-83

Despite its much-publicized financial troubles, Chrysler is well along toward finalizing a top-line, Chrysler-brand K-car for '82 introduction this fall. Mechanically identical to the Plymouth- and Dodge-brand Ks, it benefits from luxury-look front, rear and interior styling and appointments to justify its much higher price tag. Also, it may well take over the prestigious New Yorker nameplate from the company's full-size line, which is almost certain to be suffering through its final year of existence.

While there will be no conventional, U.S.-built minitruck to compete with GM's '82 S-10 and Ford's '82½ Ranger for a few more years, Chrysler will have a VW-like Omni/Horizon fwd mini. Essentially an O/H sport coupe (024/TC3) from the doors forward, the little pickup has a box in back supported by leaf springs and a rigid axle. It may be ready for '82 introduction, budget permitting, but could be delayed to '82½ or later. A K-based pickup, more serious than sporty, is also in the works for '83 or '84.

Still another K-car spinoff is the future family-car series being prepared to replace the LeBaron/Diplomat lines for '83. These roomy and luxurious stretched Ks will be comparable in size to the German Audi 5000, but will cost much less. When sporty coupe versions also replace the Cordoba/Mirada (a year or so later), these will be the largest cars Chrysler will build.

PM

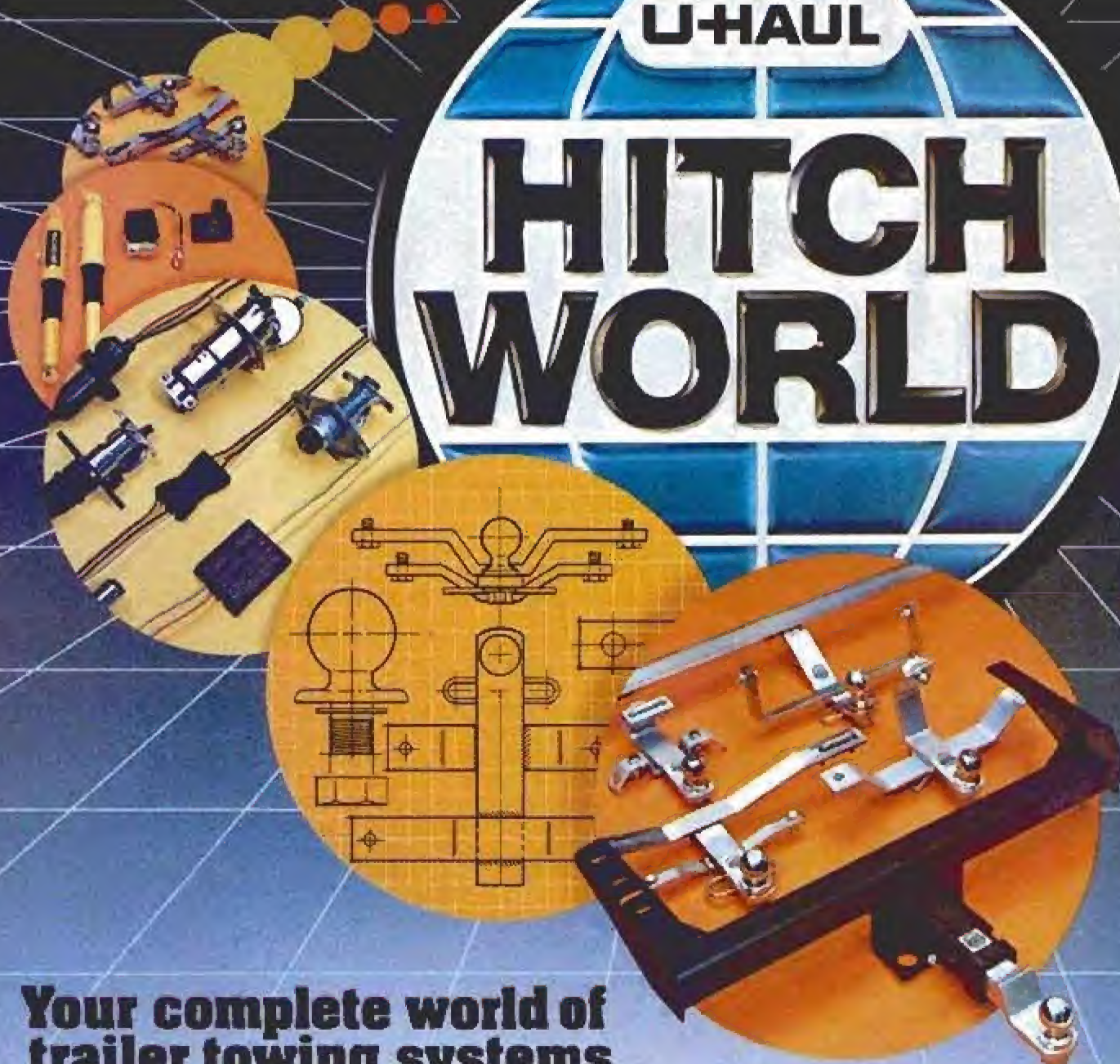




# INTRODUCING



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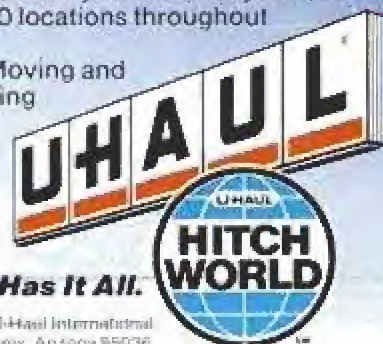
ball mounts, hitch balls, mirrors, and air shocks.

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| Leading filter 85                                   | 16 mg. tar 1.1 mg. nic. |
| Lowest brand less than 0.01 mg. tar, 0.002 mg. nic. |                         |



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10 mg. "tar", 0.8 mg. nicotine av. per cigarette by FTC method.

Warning: The Surgeon General Has Determined  
That Cigarette Smoking Is Dangerous to Your Health.



# APPLIANCE CLINIC

## QUESTIONS ANSWERED

### Condensed condenser

*None of my vacuum-cleaner attachments can properly clean the condenser in our 3-year-old Sears refrigerator. The condenser is located in the bottom of the cabinet. It's hard to reach and gets dirty fast. Is there some sort of vacuum attachment that I can get to do the job?—C. Andrew, Salem, Iowa*

We know of no attachment other than the familiar long-spouted nozzle made for most makes of vacuum hose. You might try blowing instead of vacuuming. This is what many servicemen do. You can use a bicycle pump. Study the situation: Perhaps you can rig a tool, using a dowel and a small brush. Maybe an inventive PM reader has solved this problem and will share his technique.

### Burned toast

*I have a Sunbeam toaster that had a short in it. I repaired the short, but now the toaster will not turn off. The only way to stop it is to pull the plug. The toaster goes down the way it's supposed to, but will not release. Of course, this burns the bread. Hope you can help.—Frank Chalupa Jr., Longview, Wash.*

I suggest two possible places to check before taking the toaster to an authorized repair facility. First, check the thermostat. It might be rubbing against the reflector. Second, check the contact points in the thermostat. They may have melted together, causing the problem.

### Slow spin

*I have a Ward's Signature 18-pound automatic washer, model No. LNC 6732-A33. The washer goes through the wash cycle, but the clothes are left very wet. It seems as if the spin isn't fast enough. What could cause this and how would I fix it?—Ralph Wisner, Orange, Calif.*

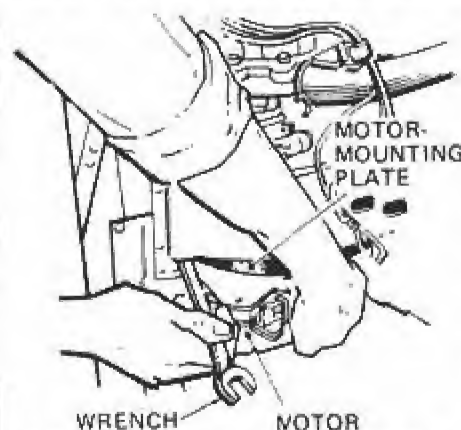
Sounds like your problem is with the top seal and bearing in the transmission. Over the years, this seal may have become distorted. Water may have leaked into the bearing assembly, causing the lubricating oil to be flushed out. The lack of lubrication causes a drag on the transmission, thus keeping the machine from achieving full speed during the spin cycle. It takes special tools and a lot of time to get into the top of the transmission to replace the seal and bearing. I would recommend contacting your nearest

Ward's repair center to have this work done. The approximate cost of parts and labor is \$80.

### Soggy wash

*We have a General Electric automatic washer model No. W.W.A. 8050L. Lately, the clothes have been coming out a little wetter than they once did. Can you help?—Guido Quinn, St. Petersburg Beach, Fla.*

Look for a loose drive belt. To check the belt, unplug the machine



To tighten a loose drive belt, loosen the three nuts holding motor-mounting plate; use one hand to pull forward on motor.

and remove the back cover. You will see the motor, water pump and clutch assembly in one unit in the lower left corner of the machine. The drive belt goes around the motor and transmission pulleys. The belt should have about a 1/8-in. deflection when you push it with your finger. To tighten the belt, loosen the three nuts holding the motor-mounting plate to the machine. Pull on the motor with one hand and retighten the three mounting nuts with the other hand.

If this doesn't solve the problem, you may have clutch trouble. I would advise calling an authorized GE service technician to check the clutch.

### SERVICE TIPS

The cold winter weather has left us for another year. This means that the airconditioning season isn't too far off. If you are in the market for an air conditioner, here are a few helpful buying hints supplied to us by Whirlpool Corp.

1. Always check the energy efficiency ratio (EER) of the model you plan to buy—the higher the better. Units of 7.5 or higher are considered high-efficiency models. They may cost more now, but they will cost less in the long run.

2. Shop early. You'll see a better selection of makes and models. If you choose a size or model that's not in stock, you may be early enough to order and receive it before the season begins.

3. Make sure you have the right size unit for your needs. Units that are too large for an area will cause the temperature to drop too fast, and shut off before removing the moisture. The result is a cold, clammy, uncomfortable room. On the other hand, a too-small unit can't cool the area and thus wastes electricity.

You should know the size of the area to be cooled when you go to buy. Multiply room length by width by ceiling height (in feet) to get the cubic feet or space to be cooled.

Count the windows in the room, noting their dimensions and type of glass (single pane, double pane or storm windows). Note the number of windows facing each compass direction and whether or not any of them are shaded during the day. Also check the type of wall construction in your house.

By having all this information handy, you will save time in the store.

4. Prices may be lower earlier in the season. If you wait till mid-summer, when temperatures are high, prices probably will be high, too.

5. Examine the electrical wiring in your house to be sure it can handle the load which will be imposed by an air conditioner. Check to see that there is an outlet close to the window where the unit will be installed. If you have any doubt, it's best to have an electrical check made by a licensed electrician.

6. Installation of a new air conditioner is best done at the beginning of the season. Many dealers will delay delivery of a unit bought early, at no charge, until the season begins. Most dealers can arrange installation for an additional charge, so be sure to ask about it before you buy.

If the unit you buy isn't too heavy, you may want to install it yourself and save this charge. In most cases, installation is simple and requires little time.

### ENERGY-SAVING HINTS

Here are six energy-saving hints for your dishwasher from the Soap and Detergent Assn. (SDA):

- Load the dishwasher according to the maker's instructions to achieve the best possible results.
- Use the recommended amount of detergent.
- Operate the dishwasher only after a full load has accumulated.
- Use a shorter cycle if it's suitable for the amount of residue on the dishes.
- Turn off the hot air during the dry cycle if water spotting isn't a problem.
- Run the appliance during off-peak hours for the local electric demand.

*If you have a question about any appliance, send it, along with the model and serial numbers, to Appliance Clinic, Popular Mechanics, 224 West 57th St., New York, N.Y. 10019. Sorry, but letters cannot be answered individually. Problems of wide interest will be discussed in this column.*



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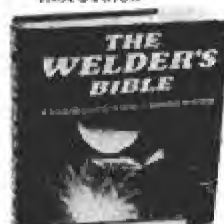
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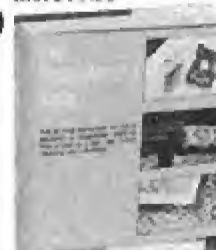
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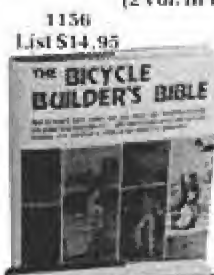
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# HINTS FROM READERS

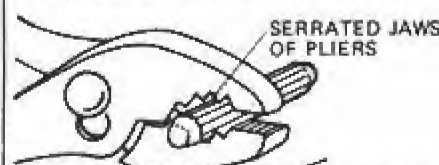
## Pipettes from straws



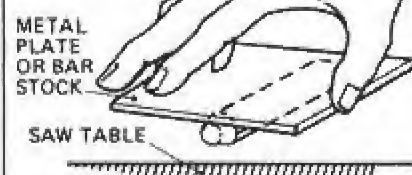
Plastic drinking straws are good substitutes for pipettes. They are translucent, disposable and also cheap. I use one to make stain and paint touch-ups, to force glue into fine cracks before clamping and to blow dust from freshly bored holes.—*P. Brady*

## Custom-sizing dowels

IF FLUTED DOWEL PEG IS TOO LOOSE:



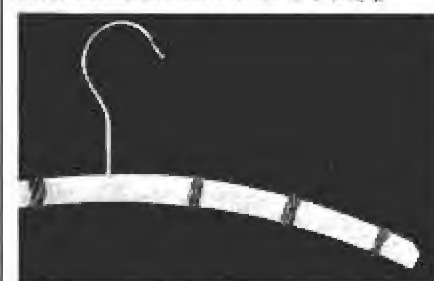
IF PEG IS TOO TIGHT:



If a fluted dowel is too loose for its intended hole, squeeze the dowel in the jaws of a pliers. If the dowel is too large, roll it between a piece of heavy-gauge metal and a saw table.

—*Edward Groh and Charles Cohn*

## Rubber bands hold clothes



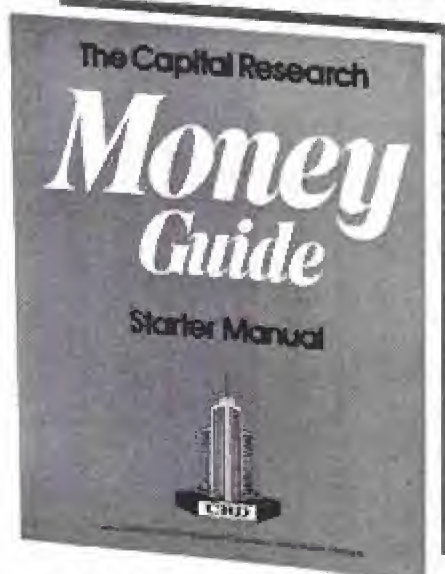
Two or three rubber bands looped at intervals around the arms of a slippery clothes hanger will prevent garments from slipping off.—*Walter E. Burton*



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# CAR CLINIC

## SOLUTIONS FOR MECHANICAL HEADACHES

BY  
MORT SCHULTZ



### Be picky

*I had to have a new pickup coil installed in the distributor of my 1978 Chevrolet. Since then, the engine has been hard to start and has been backfiring. The mechanic who did the job swears the ignition is in perfect shape, and both it and the fuel system are adjusted properly. He admits he's stumped and needs help. Can you give us some clue?—Paul Todd, Tucson, Ariz.*

A distinct possibility is the new pickup coil. If your mechanic asked his parts supplier for a high-energy ignition (HEI) system pickup coil, without specifying the model vehicle it was to be installed in, he may have received the wrong unit. Although the HEI system used in all GM cars is basically the same, the pickup and ignition coils in some Buick, Oldsmobile and Pontiac systems have a different polarity than those in some Chevrolets. Ask your mechanic to replace the coil again.

### All in the family

*My son and I are having the same trouble with our 1979 Plymouth Horizons. Every time we come to a stop at a red light or stop sign, our engines die. We've had new sparkplugs, sparkplug cables and gas filters installed. Timing and idle speed are set properly. Can you help?—Paul Williams Sr., Marengo, Ill.*

According to the Chrysler Corp. service department in Detroit, the main reasons for the trouble you and your son are having are incorrectly adjusted idle-speed and mixture settings. Setting idle speed and mixture of the Horizon and Omni is an involved process. I don't have space to explain the whole procedure here, but it involves injecting propane into the carburetor, disconnecting and plugging the EGR vacuum hose and grounding the idle-stop carburetor switch. The procedure varies for cars having airconditioning and those that don't.

Without the use of propane, there is no way of attaining a correct curb-idle speed and mixture adjustment.

The steps involved in making the adjustment are listed on pages 14-25 and 14-26 of the 1979 Horizon-Omni service manual. Instructions also apply to 1980 and 1981 models.

### Five will get you four

*I have a 1979 Datsun 310GX with a five-speed gearbox. It's virtually impossible to shift into second gear. I've returned the car to the dealer three times for adjustment, but this has failed to solve the problem. Please help.—Fran Rodgers, North Babylon, N.Y.*

Stop wasting time and gas running to the dealer for an adjustment. This transmission cannot be adjusted. The only cure is to dismantle the transmission and replace the second-gear hub assembly, second-gear synchro and second gear. There is undoubtedly a defect in one or all of these parts. In reassembling the transmission, the mechanic should take some valve grinding compound and lap the gear-to-synchro seat to remove burrs that could cause shifting to bind after the transmission is reassembled.

This problem has occurred in some Datsun five-speed gearboxes, but it is not widespread. If you're still under warranty, you have nothing to worry about. If you aren't, then take up the matter of payment with

your dealer, who should call in a factory representative. I hope you are on record as having reported the problem before the warranty expired, if it has.

### Chickens come home to roost

*Just want you to know your Saturday Mechanic article on servicing EGR systems (page 43, June '80) solved a lingering problem for me with my 1979 Sunbird. I decided to follow your instructions because of engine performance problems my dealer couldn't resolve.*

*First, I checked vacuum hoses for damage and correct routing. No trouble there. Then, as you suggested, I removed hoses and proceeded to plug each one of them, in turn, using a punch. Well, I couldn't get the punch into the hose to the EGR valve because of a small steel ball, about the size of a BB, which had been inserted in the hose.*

*I removed the ball and found that the EGR wouldn't hold vacuum. The only way that hose could have gotten plugged is by a dealership mechanic having plugged it. I called the dealer and threatened to take the matter to the GM regional service office. At this point, he told me that the emissions-control system of my car was covered by warranty for 40,000 miles, and he would be glad to install a new EGR valve, which costs \$40, free of charge. The new EGR valve straightened out the trouble and my car now runs great.*

*I'm satisfied to let matters rest with the dealer, but I wanted you to know that I think you do a very good job. Thanks.—Larry R. Heistand, Henderson, Ky.*

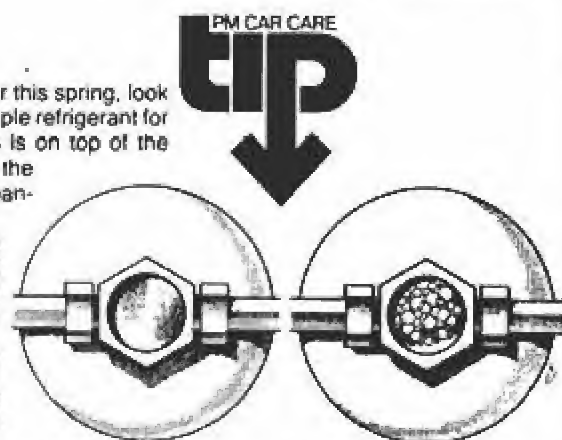
Thanks, Larry. I'm printing your story because it's a good one for readers to keep in mind. A bad EGR valve will make an engine idle rough, stall at idle, run rough on light acceleration, stall on deceleration.

(Please turn to page 48)

### Cool sight

While first cranking your airconditioner this spring, look into the sight glass to see if there is ample refrigerant for the summer. In most cars, the glass is on top of the receiver-dryer. In other cars, it is in the hose between the condenser and expansion valve.

With compressor running, the sight glass should look empty. When cold air is circulating, refrigerant is ample. If no cold air is circulating, the system may have to be checked for leaks, repaired and filled. If bubbles appear in the glass, the system needs more refrigerant and should be checked for a leak.





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HWY

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## MARQUIS

**53** CUBIC  
FEET\*\*


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## ZEPHYR

**43** CUBIC  
FEET\*\*

LYNX

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\* Compare to estimated MPG of other cars. Your mileage may differ depending on speed, weather conditions and trip length. Actual highway mileage and California ratings lower.  
\*\* Based on EPA Interior Volume Index figures. All comparisons exclude other Ford Motor Company products. Buy or lease at your Lincoln-Mercury Dealer's.



## CAR CLINIC

(Continued from page 46)

tion or detonate. There have been a number of GM EGR failures. Plugging the vacuum hose is not the answer. Replacing the valve is.

### Opening a channel

*The otherwise fine performance by my 1979 Ford Fairmont six-cylinder engine is being ruined by a problem no one can solve. Whenever I bring the car to a rapid stop, the engine starts shaking and stalls. Two mechanics swear that their tests have revealed no malfunction. There must be an answer.—Ray Meyer, Glendale, Calif.*

There is. An improperly cut air-horn gasket crept into production and was installed on some 1979 six-cylinder Fairmonts, Mustangs, Zephyrs and Capris. The gasket restricts the flow of air into the carburetor on quick stops, which causes the engine to load up momentarily on gasoline and stall.

You or your mechanics should do the following, but before doing anything, check with the dealer about the possibility of having Ford pay for the job:

- Remove the carburetor. Then

take off the air horn and old gasket.

- Find the vacuum channel, which is a small hole in the carburetor body to the left of the fuel inlet.

■ Place a new gasket (part No. D8PZ-9561-P) on the carburetor body. A hole in the gasket must line up with the vacuum channel. If it doesn't, use a  $\frac{1}{16}$ -in. drift punch to make a hole, but be careful not to damage the carburetor body or tear the gasket.

- Remove the new gasket and use compressed air to blow out the vacuum channel. Then position the gasket, reassemble and install the carburetor, and set idling speed and mixture to specification.

### Recovery discovery

*My son can't keep coolant in the recovery tank of his 1978 Chevrolet Monza. Yet we can't find a leak anywhere. We've flushed the system, replaced the thermostat and installed a new radiator pressure cap. After a few days, the recovery tank is empty, but the radiator is full. Where's the coolant going?—Herbert Brierley, Hatchville, Mass.*

Assuming that the recovery tank isn't leaking, maybe your problem is the same one Fred Soilingo of Tucson, Ariz., had.

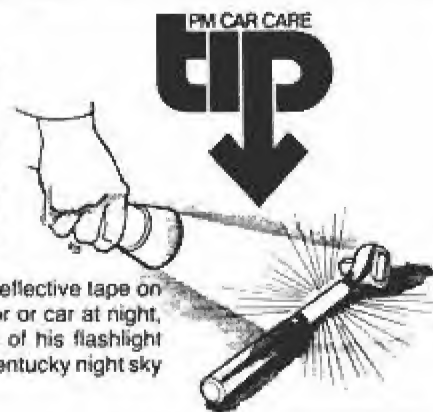
"If the coolant level in the recovery tank is maintained as described in the owner's manual, the heater

### Tape tips

Two PM readers have tape on their minds this month. Each suggests a splendid idea you may want to adopt:

■ M. Newline of Hellertown, Pa., wraps tape around the shaft of the four-way lug-wrench socket that fits the wheel lugs of his car. This quick identification method eliminates the need of having to test each socket on the lugs until the correct one is found.

■ Carl Ruh of Fort Mitchell, Ky., puts a strip of reflective tape on all his tools. Seems that Carl works on his tractor or car at night, often in a field where tools get lost. The beam of his flashlight makes tools stand out like a full moon in a clear Kentucky night sky when it hits the tape.



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## A&C GRENADIERS—THE TASTE LEADER

may rupture," Fred writes. "I have had to replace my heater, and I know of several other GM owners who have replaced theirs because of trouble with the GM coolant-recovery system. All of us had been filling the recovery tank to the COLD-level mark on the tank."

Fred became aware of trouble when he noticed coolant dripping from the heater case of his Vega. He removed the case and found the heater had ruptured.

"Fortunately, I did not have the heater on," Fred continues. "But my friend wasn't so lucky. One day, with the heater on, he smelled antifreeze. Investigating, he found an inch-deep puddle of coolant on the floor of his Corvette."

According to Fred, the siphoning process of the recovery system doesn't work in correct proportion to the ejection process. When the radiator cools off, it draws in more coolant from the recovery tank than it expels into the tank when it's hot. Someone who constantly fills the recovery tank to make up for the drop in level is only adding more fuel to the fire, so to speak, by allowing the radiator to overfill.

Fred says excessive coolant in the radiator causes extraordinary pres-

sure on the heater and heater hoses. Early evidence of this pressure is often seen as coolant seeping past tightly clamped heater hoses.

Fred's solution is to check the coolant level in the radiator with the engine cold. It should be 2 inches below the neck of the radiator. If it isn't, drain it until it is. Then keep it there.

Every few months, do check the radiator and add coolant, if necessary. In other words, forget about checking levels on the coolant-recovery tank.

### Negative response

*I have a 1976 Dodge W100 pickup truck. Its plastic gas tank has developed a leak in an easy-to-reach spot. Can you tell me how to repair it?—Jon Wilbur, Carlisle, Iowa*

Nope. Motor Vehicle Safety Standard 301 stipulates that it is illegal to repair plastic gas tanks. Your only choice is to install a new one. Sorry.

### GOT A PROBLEM WITH YOUR CAR?

Just ask Mort about it. Send your question to the Car Clinic, Popular Mechanics, 224 West 57th St., New York, N.Y. 10019. While letters cannot be answered individually, problems that are of general interest will be published in the column.

### SERVICE TIPS

■ Ford Motor Co. tells us there may be a vacuum leak between the base of the carburetor and carburetor spacer of some 1977-78 Granadas, Monarchs, Fairmonts and Zephyrs with 200- and 240-cu.-in. engines. A vacuum leak at this point leans out the fuel mixture and causes stalling and rough idling. The leak can usually be stopped by installing flat washers under each carburetor retaining nut and torquing retaining nuts 12 to 15 ft.-lb. Washers should have an inside diameter of  $\frac{3}{4}$  in. and be  $\frac{1}{16}$ -in. thick.

■ If your 1981 Chrysler K-car makes a growl at low speeds, don't panic. Check to see what kind of tires are on the car. If they are Goodyear Viva fiberglass-belted tires, the growl is normal. According to Chrysler, growling noises are caused by "aggressive tread design which offers increased traction and improved handling characteristics."

■ GM cautions that starting-aid fluids, such as ether or gasoline, must not be injected into the air-intake system of cars and trucks having diesel engines. Their use will cause "severe internal engine damage."

■ Five Keys to Better Tire Mileage and Safety is the title of an informative pamphlet you can get free by sending a self-addressed, business-sized envelope to: Keys, Tire Industry Safety Council, Box 1801, Washington, D.C. 20013.

PM



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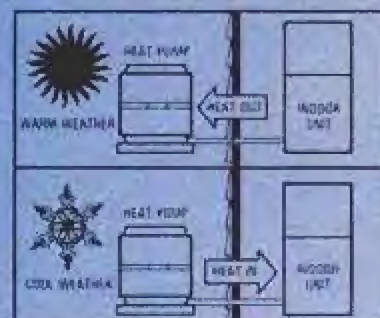
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# 5 shop 'tools' you can make for yourself

## Long vise handle for better bite

**A**fter clamping a  $\frac{1}{2}$ -in. metal rod in my vise, I found I could not apply enough pressure to hold it steady for threading. As a vise handle works on the lever principle, I extended the leverage on my vise by removing the short handle that came with it and adding a longer handle I made myself.

I started with a  $\frac{3}{4}$ -in.-dia. cold-rolled steel rod cut to a length of 10 in. from an extra socket-set breaker bar. Tap 8-32 holes in both ends of the rod,  $\frac{1}{2}$  in. deep. To tap the holes straight, I first drilled entry holes with the rod in my lathe chuck. I then started tapping each hole with the tap in the tailstock spindle and turned the lathe over by hand. When I was satisfied that the hole was straight, I finished tapping by hand with a tap wrench.

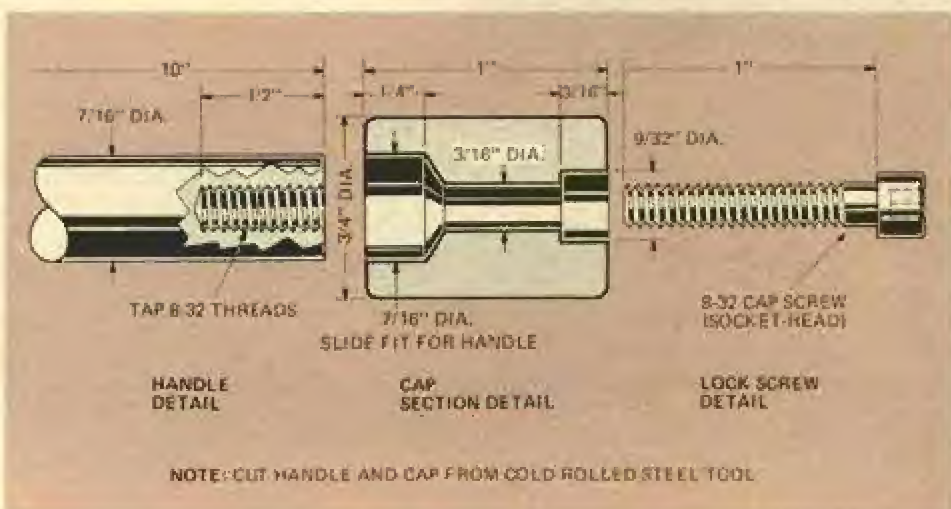
The end caps were cut 1 in. long from a  $\frac{3}{4}$ -in.-dia. cold-rolled steel rod. After facing off both ends, round over edges with a ground lathe bit or a file. Secure caps in the lathe and drill the ends at a diameter to suit the capscrew head in one end and the handle in the other. Then center-drill through and tap for an 8-32 capscrew.—*P. J. Ashley*



Apply greater pressure in vise jaw with a longer handle you can easily make yourself.



Use original caps from shorter rod if you can tap handle to fit; or make your own.





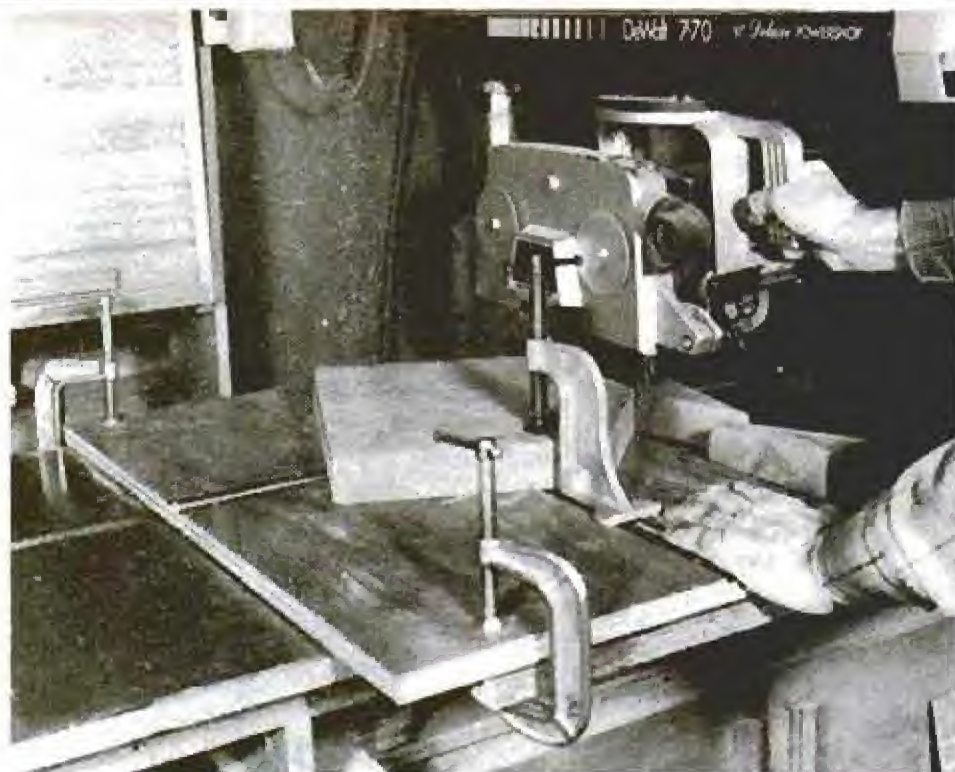
## Circle-cutting jig for radial-arm saw

**A**t first glance, you might not believe you could cut perfectly true circles with a radial-arm saw. The procedure is not uncommon, but this jig lets you cut circles as large as 32-in. diameter. One advantage of a radial-arm saw is that you can cut circles from thicker and harder woods than is possible with a band or sabre saw.

Start with a  $\frac{3}{4}$ -in. piece of birch plywood cut to the dimensions specified. Rout the dadoes and grooves for the pivot and clamp tracks—deeper cuts first, then the cuts for the strap-iron runners.

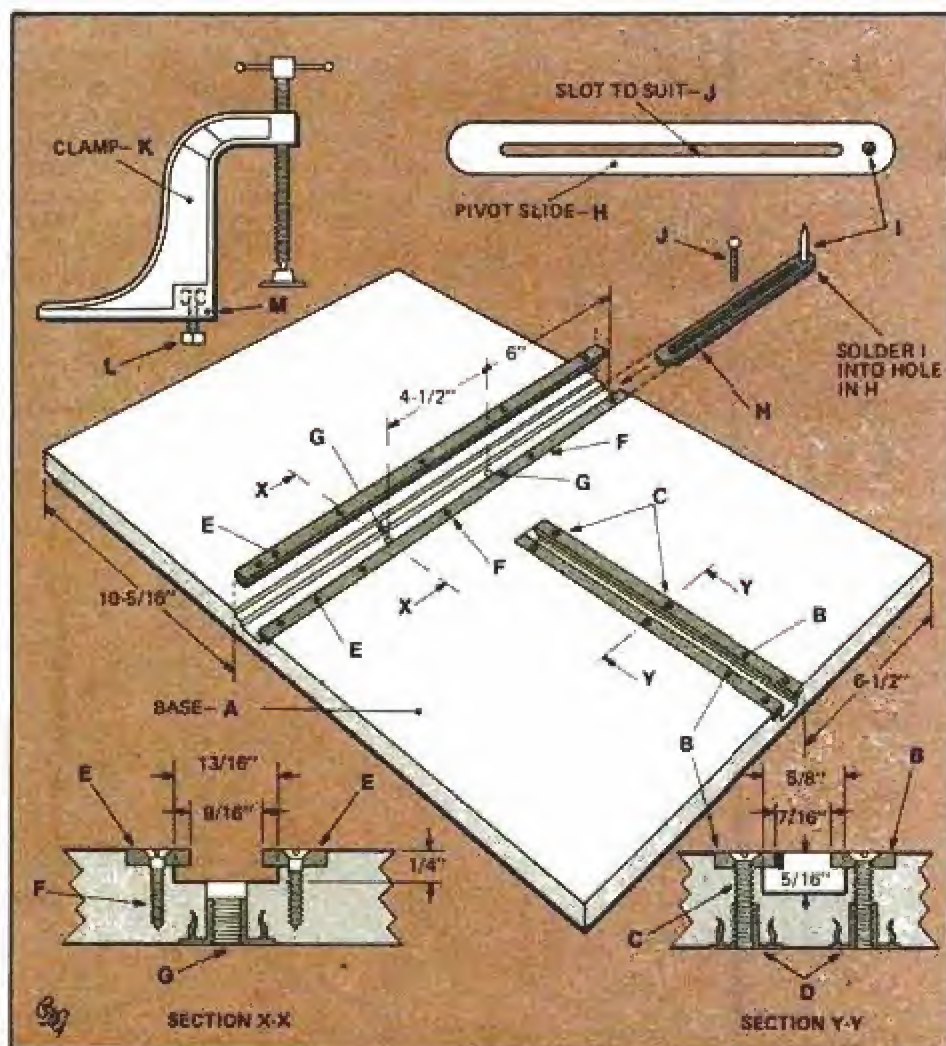
Round over the edges of the strap iron with a fine-tooth file. Attach pivot runners with countersunk flathead wood screws and clamp runners with flathead machine bolts and Teenuts. Be sure no metal edges protrude above the jig and that all metal filings are cleaned away.

Bore holes for the Teenuts in the pivot track and install the nuts. Cut the slot in the pivot slide and drill the hole for the 8d finishing nail. Insert the nail in the hole and sol-



Initial cuts are made with the workpiece firmly held down with clamp and left hand. Hand is removed above for photo clarity.

Evenly cut circles are produced in a few minutes. Final cuts are made with clamp removed and workpiece held by hand.



der. Make sure the nail is perpendicular. After the jig has been given several coats of urethane varnish, install the clamp and pivot slide. The Jorgensen hold-down clamp comes with the bolt, nut and cotter pin.

To use the jig, secure the base to the sawtable with C-clamps. Make initial cuts with the workpiece held firmly by the clamp and your left hand. After each cut, rotate the piece about  $60^\circ$  for the next cut. After two full rotations, remove clamp and hold the piece firmly by hand as you rotate it into the blade that is locked in position.

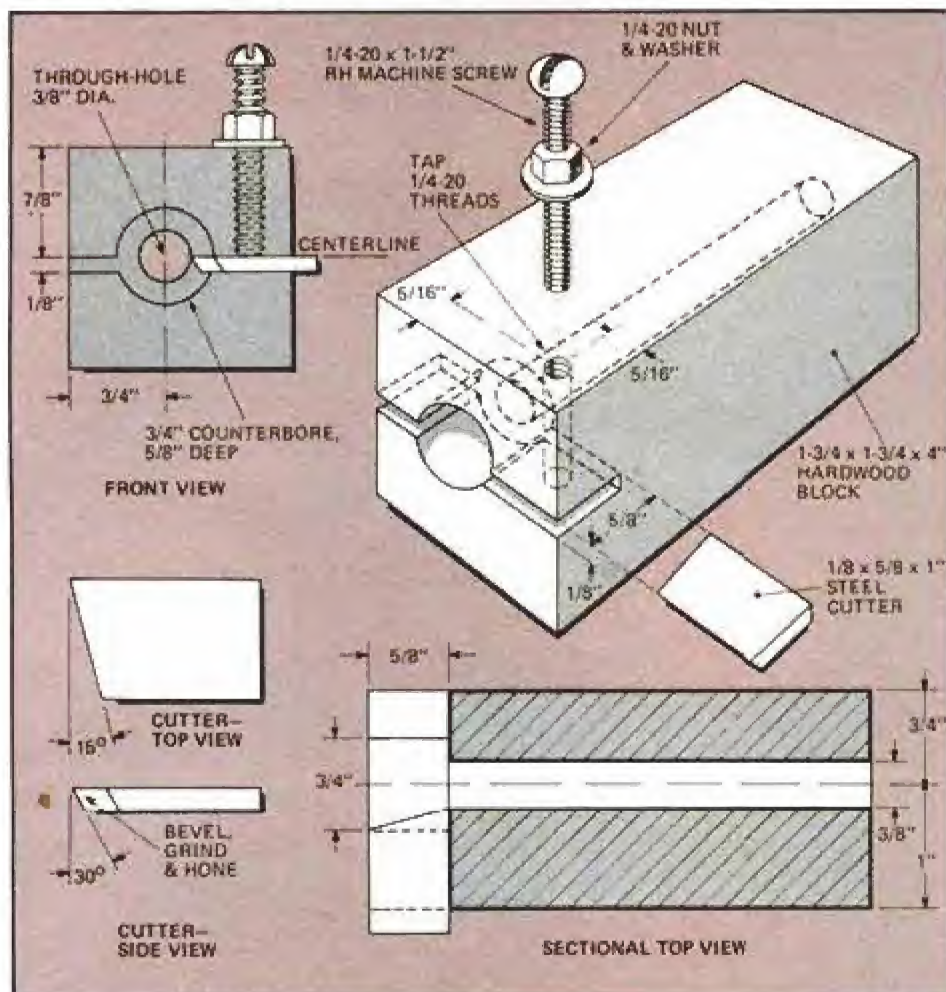
—C.E. Banister

### MATERIALS LIST—CIRCLE-CUTTING JIG

| Key | No. | Size and description (use)   |
|-----|-----|--|
| A   | 1   | $\frac{3}{4}$ x 16 $\frac{1}{2}$ x 25 $\frac{1}{2}$ birch plywood (base)                         |
| B   | 2   | $\frac{1}{8}$ x $\frac{1}{2}$ x 11 $\frac{1}{4}$ strap iron                                      |
| C   | 6   | No. 8 x $\frac{3}{4}$ in machine bolt  |
| D   | 6   | No. 8-32 Teenuts   |
| E   | 2   | $\frac{1}{8}$ x $\frac{1}{2}$ x 16 $\frac{1}{2}$ strap iron                                      |
| F   | 10  | No. 8 x $\frac{5}{8}$ in wood screws   |
| G   | 2   | $\frac{1}{4}$ x 20 Teenuts   |
| H   | 1   | $\frac{3}{32}$ x $\frac{3}{4}$ x 7" strap iron   |
| I   | 1   | 8d finishing nail, cut $\frac{3}{4}$ " long  |
| J   | 1   | $\frac{1}{4}$ -20 x $\frac{1}{8}$ " stovebolt  |
| K   | 1   | 3" Jorgensen hold-down clamp (Adjustable Clamp Co., 411 North Ashland Ave., Chicago, Ill. 60622) |

Misc.: Urethane varnish.





After stock is mounted in a lathe chuck, the jig is moved slowly toward the head stock.

## Dowel cutter works with lathe

I needed some  $\frac{3}{8}$ -in.-dia. dowels one day when the lumberyard was closed, so I decided to design and make my own cutter. You will probably find all the parts you need in your shop. Once the cutter is made, you can make dowels from  $\frac{1}{4}$ -in. square stock, or you can cut large dowels down to the size you want.

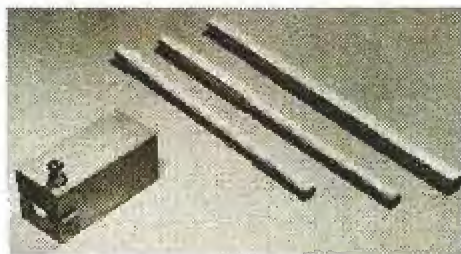
Make the jig from  $1\frac{1}{4}$ -in.-square hardwood stock. Bore a  $\frac{1}{4}$ -in. through-hole, then counterbore a  $\frac{3}{4}$ -in. hole  $\frac{5}{8}$  in. deep. A saw-blade kerf forms the slot for the cutter. Note in the drawing that the cutter edge must be on the centerline of the through-hole. Be sure the kerf is not too wide as the fit must be tight. Bore and tap a hole for the machine screw.

To cut dowels, lock the stock in the lathe chuck and feed the stock into the cutter as shown above.

—R. Juchnowski



Stock cut  $\frac{1}{4}$  in. square mounted in lathe chuck. End should be rounded slightly.

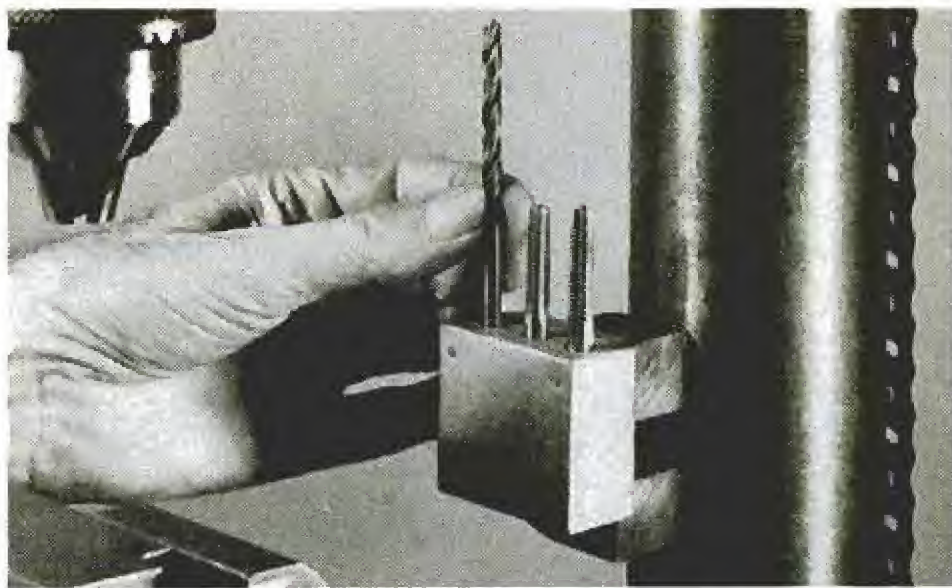


Use the jig to cut square stock or reduce larger dowels to the desired diameter.

## Handy holder for bits and taps

This easy-to-make holder for your taps and bits attaches to your drill-press column for quick use. It holds taps and bits of the same size and can save time and energy, as well as reduce mistakes.

First, cut a hardwood block to the size shown in the drawing and bore three slightly oversized holes to accommodate a straight tap, a taper tap and the corresponding twist drill. Then cut the tinplate to size and bend it around the block as shown, leaving a  $\frac{1}{2}$ -in. flange on the top. If you have trouble finding tinplate, just flatten a large tin can such as that used for coffee.



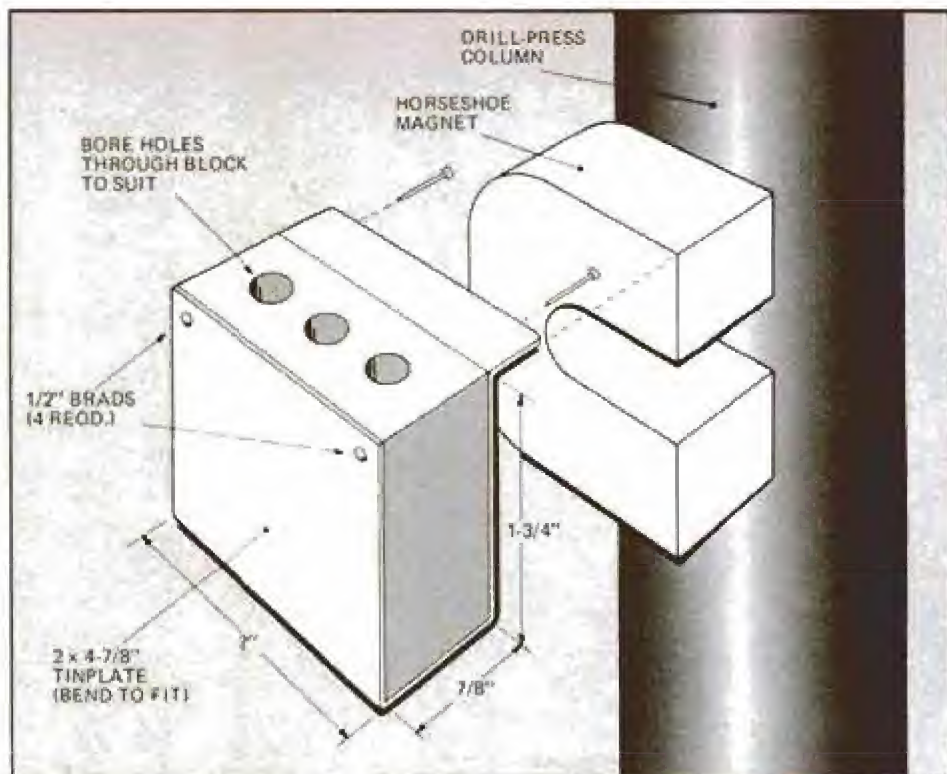
Tap and bit holder attaches to drill-press column, keeping complementary sizes together.



Finally, nail the tinplate to the block with  $\frac{1}{2}$ -in. brads and hang it from a strong permanent horseshoe magnet placed on your drill-press column or on the side of the table. The flange will prevent the block from slipping when you put a tap or drill back in.

A number of these blocks should be made—all the same size but with different-size holes to accommodate different taps and bits. Then you can make a suitable tray and have a modular tap and drill storage system. The proper block is simply moved to the drill press when you need it.

The same idea can be applied to other drill-press hardware, especially for mass-production jobs. Router bits for a spindle adapter can be kept in groups of three, as can mortising bits and chisels. You can also make a blank for a drum sander, hole saw, small center punches or whatever assortment of drill bits you might need.—Walter E. Burton



## Time-saving lathe duplicating holder

It seemed to me that I was spending too much time repeatedly picking up a lathe model when I needed to measure it with calipers. This holder is so simple that its usefulness may not be clear at first, but if you do very much duplicating, you would be pleasantly surprised by the amount of time it can save.

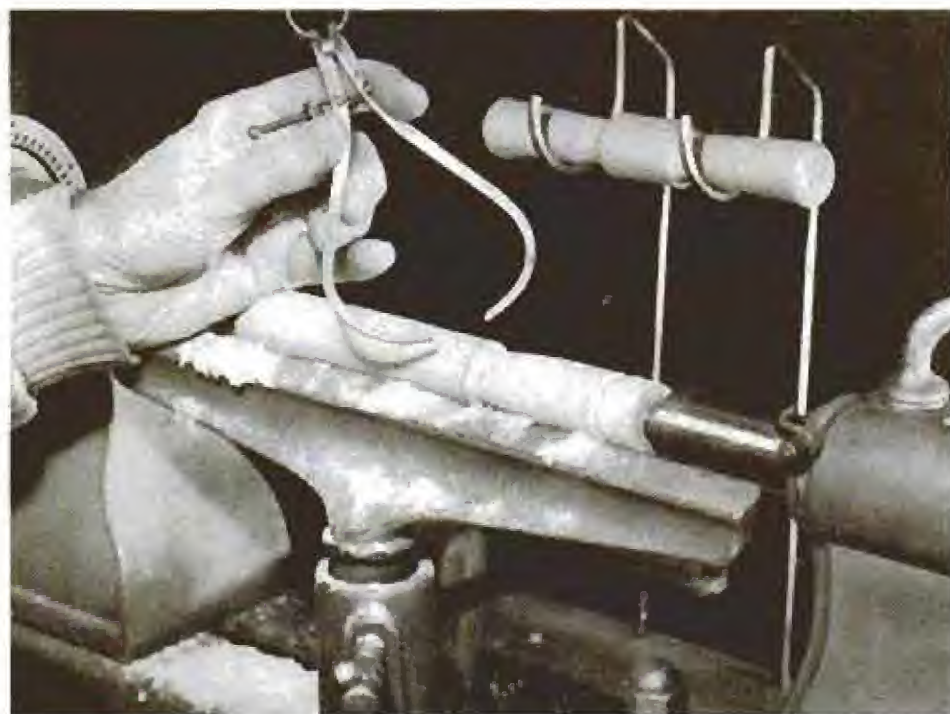
You can make the dupe holder in a few minutes, using a scrap piece of 2x4 and coat-hanger wire. The wire shown in the photographs is heavier than coat-hanger wire, but any wire adequate to support your model may be used.

Bore holes in the locations indicated. Starting with equal lengths of wire, bend as shown. Note the slight angle at the base of the wire which moves the centerline of the hook over the centerline of the base.

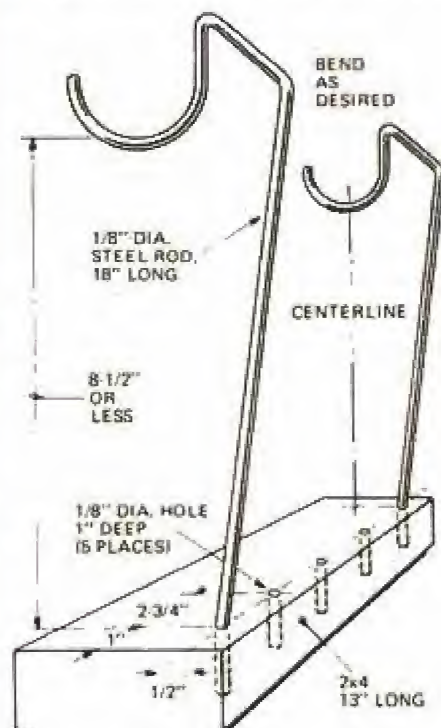
—R.S. Wilkes



Make several wire supports of different-strength wire and at different heights.



With model turning held within convenient reach, caliper measurements can be made fast.





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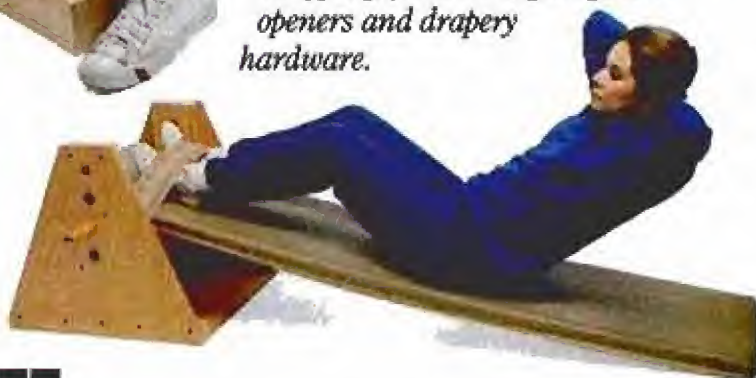
To build them you'll need some basic Stanley hardware (screws, bolts, etc.) and wood

that's available at most lumberyards. You'll also need some standard hand tools, such as a Stanley saw, hammer, bit brace. In other words, the kinds of tools you like to have around the house.

Once you've finished building—and, remember, Stanley has made these how-to plans simple, easy to follow, even fun—then go to it! As it says in the introductory remarks to this exercise program, "Fitness is good for your mind as well as your body. And it makes a lot of sense to invest in staying healthy."



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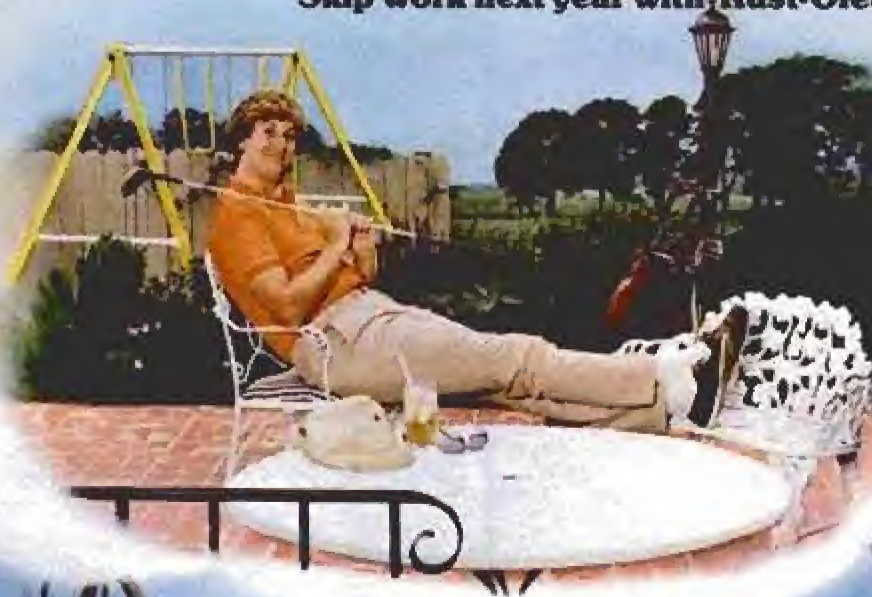
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Lower cost developing is the promise of a new, fast black-and-white film. Its silver can be recovered, even reused. And the image quality is excellent.

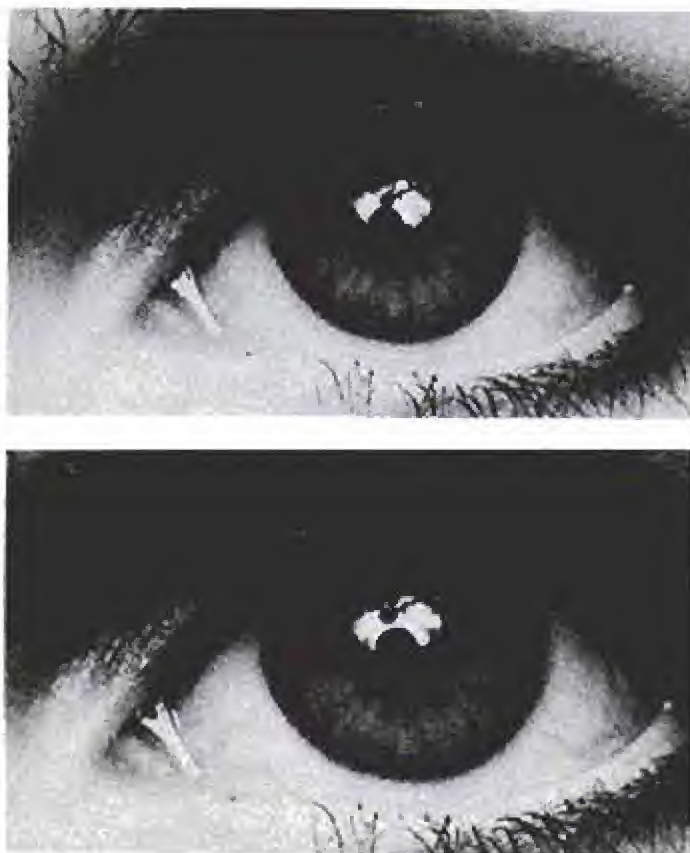
by Frank Lusk

**P**hotographic chemists have been dreaming about silverless film for years. Now it's here, or the nearest thing to it. Ilford's new XP1-400, comparable in quality to slow, fine-grain black-and-white films, should be on sale by the time you read this. We took an advance look at the European version of this unique, high-speed (ASA 400), general-purpose black-and-white film.

The film is unique in that no silver is present in the image of the processed negative. Conventional negative films expose silver halides to light. The resulting black image can almost be considered a form of silver tarnish. But XP1-400 finished negatives contain no silver.

Ilford has produced this film by borrowing technology used in color-negative films. Actually, XP1-400 is itself a monochromatic color-negative film. As in conventional color-negative films, each emulsion layer contains silver halides as well as color couplers of yellow, magenta and cyan. The bleach/fix stage removes the silver portion of the developed image and leaves a black-and-white

Ilford XP1-400 image (upper photo at right) is compared to Tri-X (lower photo). Grain structure of XP1-400 is a bit smoother and less coarse. A reason for this is that the XP1-400's image is not made out of silver halide grains. Instead, the image is a black dye. In some ways, the new XP1-400 film can be considered a color-negative film with only one color emulsion—the black. One difference noted in comparing the two films showed up when the filming speed was pushed. The pushed XP1-400 had to be printed on a higher grade of paper to have the same zip as Tri-X. The normally exposed prints (such as these) did not require unusual paper grades.



# This new film saves on silver



negative with a slight magenta cast.

A well-equipped lab can recover the expensive silver washed from the negative. An amateur must let the silver go down the drain.

The Ilford kit supplies three rolls of XP-400 film and enough chemicals in liquid-concentrate form to process them. When mixed and diluted to working strength, a liter (about 34 ounces) of developer and bleach/fix solution is produced. It's wise to use the chemicals, once they're diluted to working strength, as soon as possible to insure consistency in processing. The original concentrates and mixed stock solutions are said to keep quite well.

Unlike conventional black-and-white films, which can be processed at or near room temperature, this film is processed at slightly elevated temperatures. Anyone who has processed film before should have no trouble maintaining the proper temperatures. They are not as critical as with color film. Ilford suggests placing the working-strength chemicals,

(Please turn to page 60)





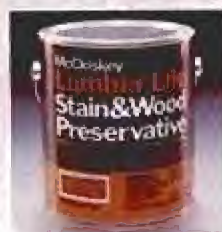
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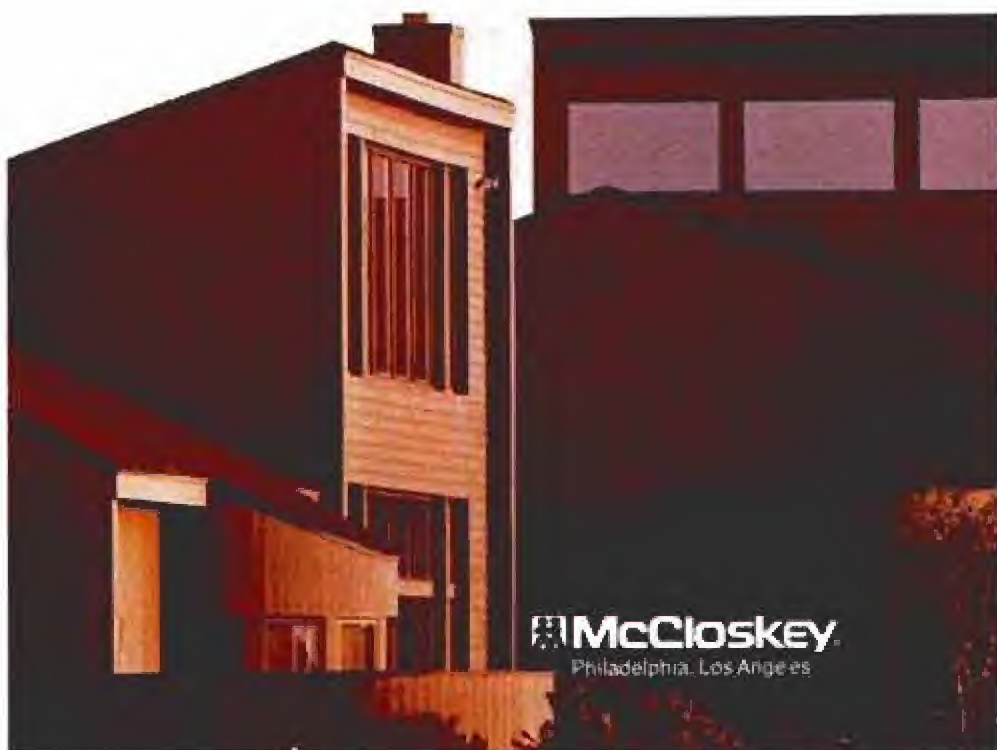
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## NEW FILM SAVES ON SILVER

(Continued from page 58)

as well as your developing tank, in a water bath about 4° F. (2° C.) above the desired temperature. This can be a bucket or even the kitchen sink. You'll need a good thermometer. Ilford suggests a temperature of 101° F. (38° C.), but also includes data for temperatures between 86° and 104° F. (30-40° C.) with corresponding processing times.

I processed my film at 101° F., followed by the recommended five minutes in the bleach/fix solution. After a three-minute wash and brief rinse containing a wetting agent, the film has a milky appearance, which clears when the film dries. For push processing (longer development to permit shorter exposures), a table provided shows extended developing times for ASA 800- and 1600-exposure indexes. With push processing, the bleach/fix times need not be increased.

## How does it look?

The pictures here show how well this film can perform. An enlarged section from a XP1-400 negative is compared to a similar section from a Tri-X negative exposed normally and developed in Kodak's Microdol developer.

I generally use Tri-X and respect its qualities. The Ilford product performed just as well. At higher magnifications, its grain structure is smoother and less coarse than that produced by Tri-X. There is little apparent difference between two normally exposed negatives.

A print from a pushed negative will show a noticeable increase in grain coarseness, with some loss in image quality.

All prints were made on Kodak's Polycontrast paper. The normally exposed negatives were printed on the same grade of paper (No. 2½) using the same exposure time. The pushed negative needed to be printed on a higher grade of paper to give the print the zip of the other two prints.

When the film is generally available, its chemistry possibly will be modified to permit its processing in standard color-negative chemistry, which it is very similar to, at any photofinishing lab. This would permit its use by even the most casual user of black and white films. We would then have a system for producing both color and black-and-white negatives using the same chemistry. In any event, this new film is superior enough to be considered a significant advance in black-and-white film technology. **FM**



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Model 829 extendable truck & camper



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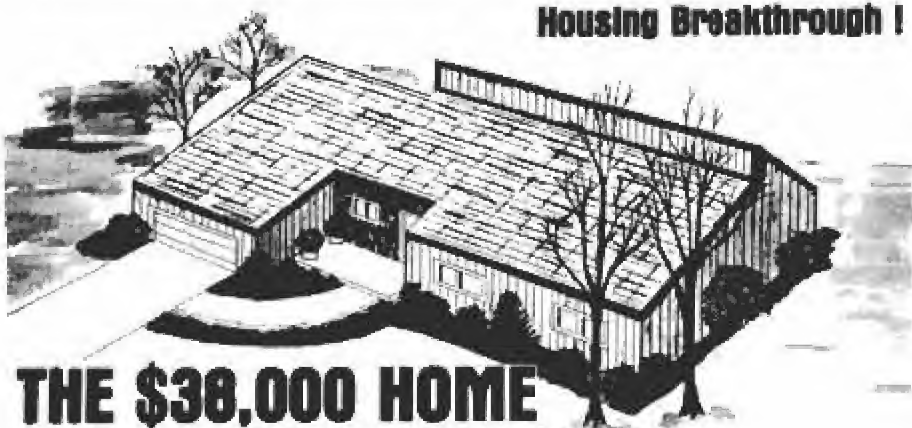
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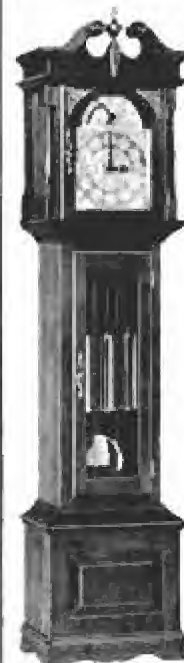
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# The truth about those EPA mileage figures



This might be the only way some cars can achieve EPA estimated mileage figures.

Sometimes your car may get better mpg than the EPA figure—most times less. Here's how to predict the exact mileage to expect.

by Mort Schultz

Last September, New York Supreme Court Justice Edward Greenfield dashed the hopes of many car owners who were fired up over bloated Environmental Protection Agency (EPA) fuel-economy estimates. He ruled that car buyers have no basis for bringing suit if their cars fail to attain the EPA numbers.

The case before Justice Greenfield involved a 1980 Lincoln Continental Mark VI. The EPA estimates that this car should get 15 miles per gallon (mpg). But not even the disclaimer issued by the EPA and manufacturer that "your mileage may differ depending on how fast you drive, weather conditions and trip length" prepared the Lincoln's owner, B.J. Sherman of New York City, for reality.

When one expects to get 15 mpg, or thereabout, and one gets only 7 mpg, as Sherman says his Lincoln does, one tends to get a mite testy, which Sherman did. So, he brought suit against the dealer and Ford Motor Co. to get some return on his mileage loss—which was in excess of 50 per-

cent of the manufacturer's claim.

No dice, the judge said. The EPA mileage figure "represents limited expectations" and is, in fact, "an educated estimate."

So what good are EPA estimates? It depends on what you expect from them.

"The intent of estimates is to let car buyers compare and rate fuel economy performances of cars in the same class," says David Kulp, manager of fuel economy planning at Ford. "Estimates are estimates. They are not actual road performance specifications. When a person who buys a new car expects to get the mileage that is advertised, he will be disappointed in most cases."

Indeed. But it seems, to this observer anyway, that the automobile manufacturers are taking advantage of loopholes in the law to present grossly inflated estimates to the public.

For example, most car advertisements give two mpg figures—the official EPA estimated mpg and a highway estimated mpg, which is much greater than the official figure. For instance, advertising for the 1981 Dodge Aries cites 25 mpg as the official EPA estimate and a whopping 41 mpg as the highway estimate.

"Human nature being what it is, people focus on the higher number," says Peter Hutchins, project manager of the EPA technology assessment and evaluation branch in Ann

Arbor, Mich. "The owner of a new car is probably going to have a shortfall in fuel economy between the official EPA estimated mpg and the mpg he or she actually realizes on the road."

Where does this estimated highway mpg figure come from and why is its use permitted? Answers to these questions require a knowledge of pertinent laws and an understanding of how the current program evolved.

## The Clean Air Act

Before a new car is certified by the EPA, it is tested by that agency for emissions as specified by the Clean Air Act. The Energy Policy and Conservation Act (EPCA) of 1975 also makes the EPA responsible for testing fuel economy. The EPCA requires that the EPA publish and distribute pamphlets listing test figures of new cars. (If you want one for the 1981 models, ask a new car dealer for it.)

The EPCA further requires that manufacturers place labels on every new car citing the official EPA estimated mpg (for city driving). In their advertisements, most manufacturers also cite the estimated highway mpg.

Emissions and fuel economy tests are performed simultaneously in the laboratory. Fuel economy estimates are obtained from emissions test data derived during two test cycles: the Federal Test Procedure (FTP)

(Please turn to page 67)



Take the road to flavor  
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Warning: The Surgeon General Has Determined  
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## EPA MILEAGE FIGURES

(Continued from page 64)

and the Highway Fuel Economy Test (HFET).

For 1977 and 1978 models—1977 was the first year mpg estimates had to be reported to the public—the mpg estimates attained from both cycles were reported as official EPA figures. The mpg attained by the FTP was designated as the "EPA estimated city mpg" figure. The mpg attained by the HFET was designated as the "EPA estimated highway mpg" figure.

An "EPA estimated combined mpg" figure was also cited. The combined figure became the basis for estimating the Corporate Average Fuel Economy (CAFE) of all cars produced by a manufacturer in a model year. The CAFE of a manufacturer's entire fleet of cars for any one year has to meet or exceed the CAFE set by Congress for that year, or the maker will be penalized.

Beginning with 1979 models, only miles per gallon attained by the FTP are cited as official EPA estimates for city driving. The FTP figure is considered more in keeping with actual on-the-road mileage than the estimated highway and combined

mpg figures. Thus, the city test figures are the only ones in 1979, 1980 and 1981 EPA mileage booklets.

However, Highway Fuel Economy Tests are still performed in the EPA laboratory and combined with FTP data to determine if a manufacturer meets CAFE requirements. The rub is that manufacturers are allowed to use HFET figures in advertising.

"Why shouldn't we be?" asks Kulp. "When a car manufacturer introduces a new innovation that has an impact on highway fuel economy, such as Ford's overdrive automatic transmission, why shouldn't he be allowed to advertise the increase in mileage the innovation provides?"

The EPA can't argue with this logic. "As long as there is no law prohibiting it, manufacturers can cite HFET figures," Hutchins states. "Highway fuel economy figures, which seem a lot more appealing than official EPA estimates, help sell cars."

But is the use of these figures in advertising a deceptive selling practice? You answer that question.

### Legal loopholes

There are other discrepancies in the way regulations are interpreted that tend to inflate mpg estimates.

Test vehicles are supposed to be the same as production models in all material respects. However...

■ Manufacturers are allowed to shave weight from vehicles they send to the EPA for testing. A test car isn't required to have a spare tire, jack or rear seat.

■ Manufacturers are allowed to submit prototype cars with engines that take advantage of engine tolerance limits which minimize internal resistance and maximize mpg. For instance, test engines can be equipped with lower-tension valve springs, smaller water-pump impellers, lower-tension piston rings and greater clearance between bearings and journals than production engines.

"All that the EPA knows about the internal configurations of engines is what manufacturers tell us, since we never disassemble engines," Hutchins says.

■ Manufacturers are allowed to establish points at which automatic transmissions will shift. As long as these points are within tolerance limits, they may not be the same shift points designed into production transmissions.

Manufacturers claim that it's im-

(Please turn to page 68)

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This one power-fed tool—  
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Jay Hedden, Editor  
Workbench Magazine

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## EPA MILEAGE FIGURES

(Continued from page 67)

possible to give the EPA production models to test—that only prototypes can be offered.

"In order for the manufacturer to be able to start making production cars, the EPA first has to certify that the prototype passes emissions tests," Kulp points out. "Making the production car and then having it tested is putting the cart before the horse. What do we do after spending all that money if the car doesn't get certified?"

### Whom do you trust?

So, what is the answer to inflated fuel economy estimates? Some say, "Dump the program." But this isn't likely to happen.

In all likelihood, the EPA will probably jockey to get test estimates closer to real-world driving. According to Larry Landman of the EPA's certification branch, "We are studying a number of different proposals that may let us apply a correction factor to test data so estimates can be made more realistic."

Obtaining a correction factor is the type of challenge which appeals to PM. So, I was assigned to run our

own tests and compare the results with official EPA fuel economy estimates—that is, the FTP (city driving) figures.

How did I do? According to Peter Hutchins, the correction factors I obtained will make estimated mileage much more realistic for all cars than the EPA mpg estimates.

For testing, we used a 1979 Ford Granada with a 302-cu.-in. V8 engine

and automatic transmission. It was in perfect mechanical shape—tires inflated properly, engine tuned to specification and so forth.

### The real world

Unlike the FTP, which is performed under controlled laboratory conditions, ours was a road test.

Keep in mind that the EPA estimated (city) fuel economy for the 1979 Ford Granada used for my tests is 16 mpg.

Here, in sequence, are the tests.

1. I started the Ford's cold engine and allowed it to idle for one minute. The engine consumed 97 cc of fuel, equivalent to 1.54 gallons per hour.

I drove the car 1.4 miles to the expressway at an average speed of 16.8 miles per hour (mph), using a quantity of fuel equivalent to 9.6 mpg. Then, I drove five miles on the expressway at an average of 33 mph to warm up the engine.

The initial tests proved that a great deal of fuel is consumed when a cold engine is allowed to warm up with the car sitting idle.

2. I ran three separate cruising tests on the expressway, going with the wind. According to the weather bureau, the wind was blowing at an

(Please turn to page 80)

| CHART 1           |                      |      |
|-------------------|----------------------|------|
| Distance traveled | Average speed (mph)* | Mpg  |
| 3 miles           | 55.7                 | 18.4 |
| 3 miles           | 54.5                 | 19.1 |
| 4 miles           | 54.5                 | 21.5 |

| CHART 2           |                      |      |
|-------------------|----------------------|------|
| Distance traveled | Average speed (mph)* | Mpg  |
| 4 miles           | 54.3                 | 18.6 |
| 3 miles           | 54.3                 | 19.5 |
| 3 miles           | 56.5                 | 19.8 |

\*Cruise control on.

### Both mowers include:

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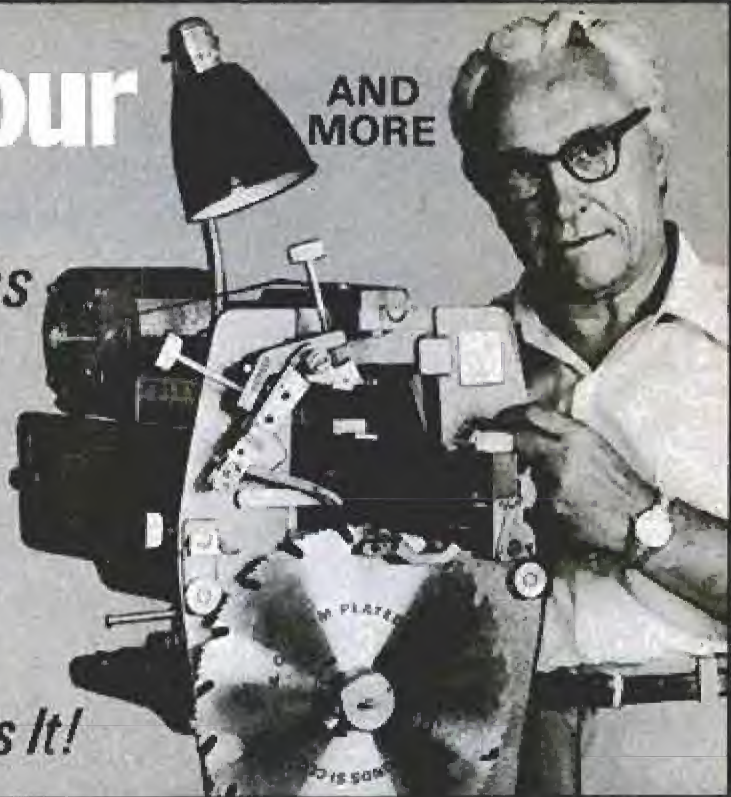


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**This can be one of the most important decisions you ever make**  
Going into business for yourself can be the most exciting and rewarding decision you're likely to make in your lifetime.

Owning your own business brings you a sense of independence. You're the boss, setting your own work hours. Your own effort builds the business for yourself and your family. You can achieve great satisfaction and profits, if you choose and manage your business wisely. That's why so many men, just like you, are cashing in on the big profits to be made in this fast-growing service field.

The sharpening business allows you to get started with only a minimum investment, requiring little space and effort for a successful operation. It lets you build and expand as fast, or as slowly as you like. You pocket most of the money you take in, because there are exceptionally high profits with no investment in merchandise.

If you need only \$200 or \$400 extra income each month, a sharpening business is ideal for spare time. The additional dollars can be SPENT for more of the good things of life. Or they can be SAVED in a rainy-day fund that the family can bank on.

**More sharpening businesses are needed every year**

As original equipment continues to climb in cost, owners are becoming more concerned that the equipment be maintained so that it performs like new. This means more companies, contractors, carpenters and home owners are having their old saw blades and tools resharpened many times, where in the past, they would have replaced them with new blades or tools. This is where you can step in with the much needed service of sharpening saws and practically any kind of tool.

**Read What These Foley Shop Owners Say:**

**Shop will gross \$40,000 ...  
... likes being independent**

*"I worked in various industrial jobs for years, and always wondered if I could make money for someone else, why I couldn't do it for myself. So after losing my regular job, I opened my Foley sharpening shop in the basement of my home. I only had a minimum of cash to start with, but Foley financed the balance. My shop will gross over \$40,000 this year, and I like the feeling of running my own shop without answering to someone else."*

**William Wescott  
Willoughby, Ohio 44094**



**Husband and wife have a going spare time shop**

*"I'm a construction foreman, and my wife is a nurse's aide. Our Foley shop fits in nicely with our regular jobs, and we earn extra money. Our sons help out too, so ours is a real family business."*

*"I'm still too young to retire, but when I do I'll have a very good business built up. Foley equipment helps us to do good work and brings shop customers back with more jobs on a regular basis ... we have a lot of repeat business the year around."*

**Victor Kosloski  
Sturgis, Michigan 49091**



**This FREE BOOKLET has helped thousands**

Thousands of good men have been inspired by this fact-filled book into making that first important step of starting their own business.

It can be yours just for the asking. Right now, while this is still fresh in your mind, fill-in the coupon below. We will send your FREE copy of "Opportunities in a Sharpening Business of Your Own". There is absolutely no obligation and there are no franchise fees in starting your Foley Sharpening Business.

**CLIP OUT AND MAIL THIS COUPON TODAY**

*If coupon has been removed, just send name and address to:*

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Minneapolis, Minn. 55418  
or call Toll Free 1-800-328-7140  
(Except in Hawaii or Alaska)**

**Foley Manufacturing Company  
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**Foley**

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Now with  
Fresh Clean Scent



# Spraying tips for lawn and garden



To mix the optimum pesticide solution, use measuring utensils and follow all directions and precautions on the label (inset). If one tablespoon of pesticide is recommended, two tablespoons won't be twice as effective. Mix only the amount you need. Spray on target (above), especially under leaves, where insects settle and plant disease begins. A haphazard application won't curb insects or stop plant disease.

**A**n effective spray program can mean the difference between a garden that thrives and one that yields little. Here are some helpful spraying tips from H.D. Hudson, the spray and duster makers.

First, identify the pest so that you use the *right* pesticide. Your cooperative extension service or county agent can help identify pests. Three major groups are: insects, weeds, and plant diseases.

Most of us know that insects are controlled by insecticides. You may not know that mites and ticks are controlled by miticides; snails and slugs are controlled by molluscicides. Kill weeds with herbicides. Some plant diseases are fungi, controlled by fungicide, and nematodes, controlled by nematicide.

Timing is important. Try to spray early, or in the evening, when there is little wind to disperse spray. Heat quickly evaporates some pesticides and leaves a harmful residue.

Wear long sleeves and pants. Wash off any spray that gets on you.

FM

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SEE YELLOW PAGES FOR NEAREST DEALER

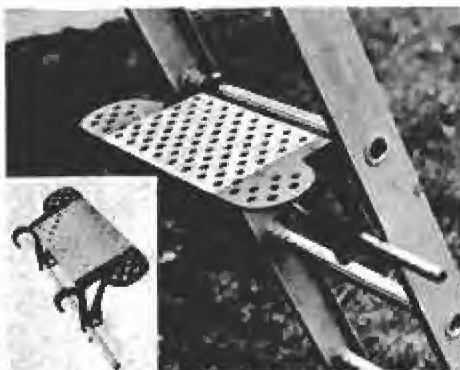


# PM WORKBENCH

PM EXAMINES PRODUCTS AND SERVICES

## Ladder footrest

This handy accessory hooks over a ladder rung and becomes a comfortable platform. Made of durable aluminum alloy, the nonskid platform is lightweight and easily moved. The two-position support brackets permit adjustment for both normal and



Wide, flat, foot support makes long ladder sessions tolerable, decreases discomfort. Spring hook keeps the rod in place.

near-vertical ladder angles. The unit works for rungs 12 to 22 in. long.

Available by mail from Camden Diecasting Inc., Box 94, Camden, N.Y. 13316, the painter's aid is \$26.95 postpaid.—*Rosario Capotosto*

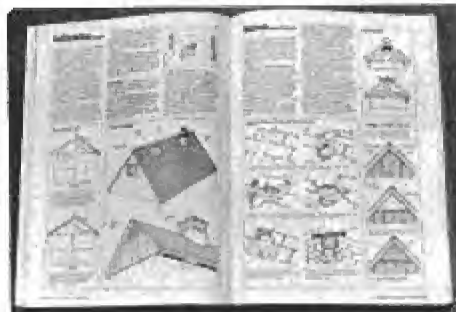
## Doing and complaining

I've seen two good books recently. The first, called *Energy Saving Projects for the Home* (Ortho Books, 575 Market St., San Francisco, Calif. 94105) is a comprehensive overview of energy concerns, from caulking tips to the financial facts of changing heating systems.

It has lots of information on insulating, as well as hints on keeping appliances running efficiently. Both active and passive solar designs are



Numerous sensible ideas to save energy.



Book has large, easy-to-follow diagrams.

discussed; the book even gives instructions on cutting, stacking and burning firewood. It costs \$4.95 at bookstores and home centers.

The second book, called *Consumer's Resource Handbook*, is about the art of complaining. This free book tells you how to better your chances of being happy with a product before you buy, and what to do if you're unhappy afterward. Write to Consumer Information Center, Dept. 619-J, Pueblo, Colo. 81009.

—*Steve Willson*

## Elegant pocketknife

For elegance in pocketknives, look to the Khyber Designer Collection. The unique styling and exotic handle materials such as abalone shell, coral bone and rosewood give each knife the distinctive look of fine jewelry. But these knives are more than just good-looking.

They feature cutlery type, high-



Handsome ebony-handled knife boasts contemporary styling (top) and a stainless-steel blade. The knife's keen edge cuts cross grain with ease and stays sharp.

quality, stainless-steel blades honed to a razor edge, and a safety-engineered thumb release that locks the knife's blade open during use.

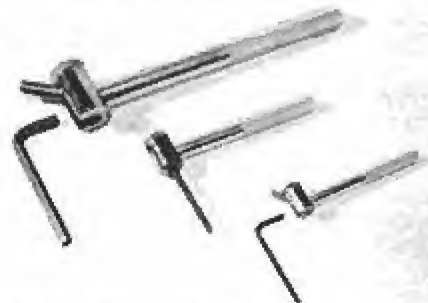
The model No. 2810 ebony-handled knife shown lists for \$13.50 postpaid. From Ka-Bar Cutlery Inc., 5777 Grant Ave., Cleveland, Ohio 44105.—*H.W.*

## Hex key holder

Saf-Kee holder for hex wrenches has a comfortable handle that permits great leverage and protects the user from slipping or breaking wrenches.

Either end of the wrench can be inserted in the holder and snugged with a flick of the tensioned finger bar. The top of the holder head is cupped for snug finger pressure.

The set of three holds hex wrenches from  $\frac{1}{16}$  to  $\frac{1}{4}$  inch and costs \$49.95 postpaid. Available individually from



Holders for wrenches come in three sizes.



Comfortable handle increases leverage.

P.X. Industries, Inc., 199 Winter St., West Hanover, Mass. 02339.

—*Rosario Capotosto*

## Price update

The lumber mill attachment for chain saws previewed here in Mar. '81 (page 46) costs \$90 postpaid, instead of the price originally stated. Order it from Boyce Industries, 406 South Chester St., Gastonia, N.C. 28052.

If you've come across a new product with some special features let us know about it. Write to PM Workbench, Popular Mechanics, 224 West 57th St., New York, N.Y. 10019.

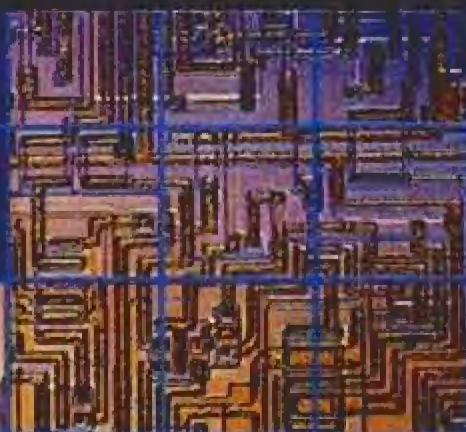


# WE DIDN'T GET TO BE THE LEADING AUTO SOUND SPECIALIST BY STANDING STILL.



Simulated LED readout

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**WE KNOW DRIVING IS A FULL-TIME JOB.** So, we pioneered the use of practical features such as push-button tuning. At Delco we specialize in developing sophisticated electronic inner circuitry which eliminates the need for distracting switches and tiny controls.



**WE MAKE SPEAKERS FEEL AT HOME ON THE ROAD.** Extreme heat, humidity and vibration in the automotive environment can quickly deteriorate speakers. All of our standard speakers and our optional Delco Sound™ extended range speakers are designed to perform in this severe environment.



**HOME STEREO STANDS STILL.** Car stereo doesn't. To compensate for vehicle movement, Delco ETR™ cassette units contain sophisticated features such as: microprocessors, keyed AGCs and audio processor circuits to improve reception. Automatically.

**THE LAST THING YOU WANT IS STATIC.** A car stereo is surrounded by electrical components which can generate static. Because we know the entire electrical system of GM vehicles, we build features like impulse noise blankers into Delco-GM stereo systems to help minimize interference.



**BELIEVE YOUR OWN EARS.** When you buy your new GM car or truck, ask your dealer to demonstrate a Delco sound system. Your ears are in for a pleasant surprise. Nobody knows the inside of GM vehicles quite like the automotive sound specialists at Delco Electronics Division of General Motors Corporation.

**Delco GM**

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- This will end up being your "best tool in the shop". To build, few tools are necessary. All steel parts are considered stock items. Any 1/2-hp electric motor (or larger) can be used.

Send \$3.75 to:

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## LETTERS

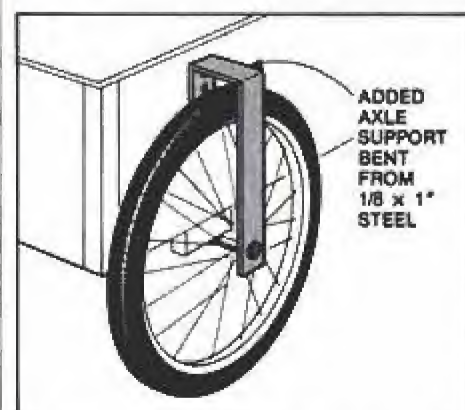
(Continued from page 10)

a lighted toggle switch can be used. In this case, the switch toggle acts as a reverse pilot light—that is, the light in the toggle is on when the load is off and vice versa. Such switches are readily available and offer the added benefit of a "finding light" if the switch is located in a dark area.

R. C. CRESSMAN  
MANAGER, PRODUCT SAFETY  
GENERAL ELECTRIC CO.  
WARWICK, R.I.

### A good tip on cart axles

I built the garden cart shown in your July '80 issue (*Build PM's Rugged, Lightweight Garden Cart*, page 110). The cart turned out fine, but the 1/2-inch axle doesn't adequately sup-



Side brackets added to PM's garden cart help support outboard ends of axle so it won't bend under heavy loads. It may be necessary to increase axle length slightly to accommodate the extra thickness of the brackets and two additional washers.

port the wheels. It bends at the hubs and could break.

I solved the problem by bolting extra steel brackets to the sides of the cart (see drawing above). They hold the wheels steady.

JOHN C. BASTIAN  
NEW CARLISLE, OHIO

While the problem should not occur unless the cart is heavily loaded, adding the outer brackets is an excellent idea. We chose the 1/2-inch axle because it readily fits bicycle wheels, but another alternative is to use a heavier 3/4-inch axle, which we also suggested in the article. For those interested, copies of the garden-cart plans can be obtained by sending \$1 to Popular Mechanics, Box 1014, Radio City Station, New York, N.Y. 10101.

(Please turn to page 85)



# PM ELECTRONICS MONITOR

## Videodiscs: What's ahead?

The one thing you can do with a videodisc that you can't do with a TV is interact with it. The first interactive videodisc, just released, is called *How to Watch Pro Football*. Because the disc lets you search frame by frame, back and forth, the narration can lead you through complex maneuvers.

But future interactive discs will make this one seem primitive. We envision keyboard add-ons to videodisc machines that will allow you to have full control over a myriad of functions. With 54,000 frames of picture per disc, and keyboard control, you will be able to walk the halls of the Louvre at your own pace, visit strange cities, even look into the distant past—and it will all seem remarkably real. The disc will become a new educational medium that will use TV as a creative display.

The next development will be a videodisc you can record on as well as play. Most see this as something that's far in the future (more than 10 years away), but we disagree. New developments in related electronic fields promise play/record videodiscs within three years.

The developments we refer to are in liquid-crystal technology. Videodisc platters are basically mirrored surfaces. Microscopic pits in that surface bounce laser light from the disc machine so that the disc's computer can decode a TV picture.

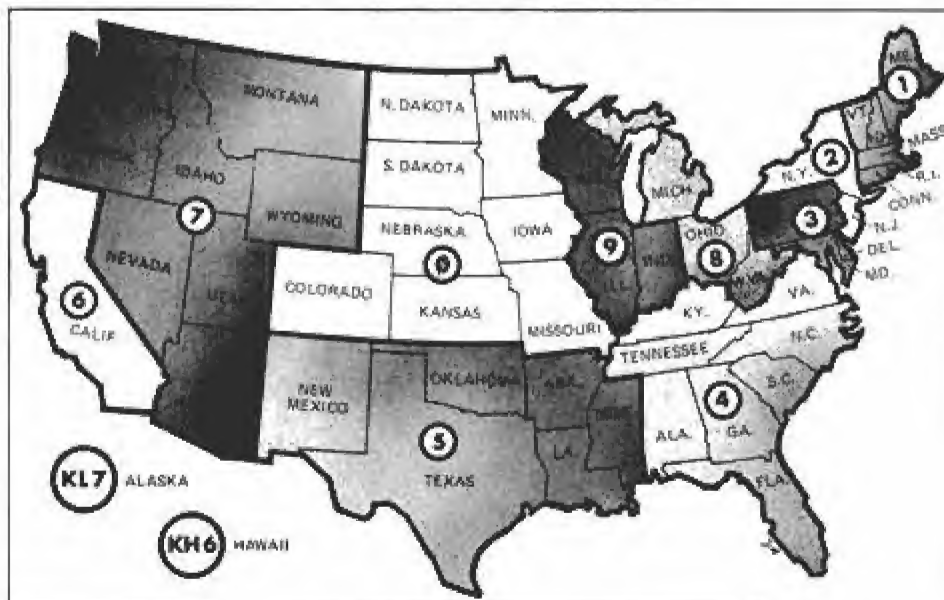
Liquid crystals are now being made as small as integrated circuitry and almost as fast. Picture a disc coated with these crystals. Recording will no longer involve burning pits into the surface. Tiny liquid crystals will be activated to act like minuscule mirrors. In this way, a picture may be coded—and later erased.

Of course, both these developments depend on the emergence of the laser disc with its digital encoding and fast access times. Should the capacitance system (RCA) win out over the laser (Magnavox/Pioneer), some believe that the videodisc market may stagnate forever into simply canned movies.

Only the future will tell whether the videodisc is really the forerunner of a new world of consumer electronics—or a flash on the TV tube.

## The piracy question

The people who market home-computer software are more worried



## New ham-radio call signs

Ham-radio call signs have changed. The areas are still the same (see map); a fellow with a "4" in his call is somewhere in area No. 4. But some hams now sport calls starting with letters other than the familiar "W" or "K." This reflects

shorter calls available to holders of higher class licenses. The FCC ran out of the "W" and "K" series. So now, for example, you will hear calls starting with N2 or AC4—but the number is still the locator.

than even the Caribbean arm of Interpol is about pirates.

Most computers are designed to save the programs stored in their memories. This is great for many purposes.

But suppose a computerist is running a space-war game he paid \$20 for—or a word-processing program that cost \$150. Enter the good friend with a like computer who asks: "Can you give me a copy?"

With an unprotected program, it is as simple as typing SAVE. But such a pirated program earns no money for either the original programmer or the distributor.

Now, much computer software is sold "protected." Elaborate coding schemes are used so that the software cannot be copied.

This leads to new problems. A user cannot back up an important program with a copy—this is necessary since discs and tapes can go bad. Some companies sell protected backups at inflated prices. Also, many pirates care less about using the software than the challenge inherent in breaking a code.

Worse, copy-protected software cannot be changed. So the user can't customize the program. This negates one of the computer's best features.

As always, someone builds a better mousetrap. In this case, it's *The Locksmith* program from Omega

Software (\$74.95 from Omega Inc., 222 South Riverside Plaza, Chicago, Ill. 60606). On an Apple II, this program will duplicate almost all copy-protected software through an ingenious system.

The question is: Will this hurt the industry? Some software houses feel that this spells the end of their livelihood. Only a few of the dozens of software suppliers and store owners we spoke with felt that this wouldn't affect them adversely.

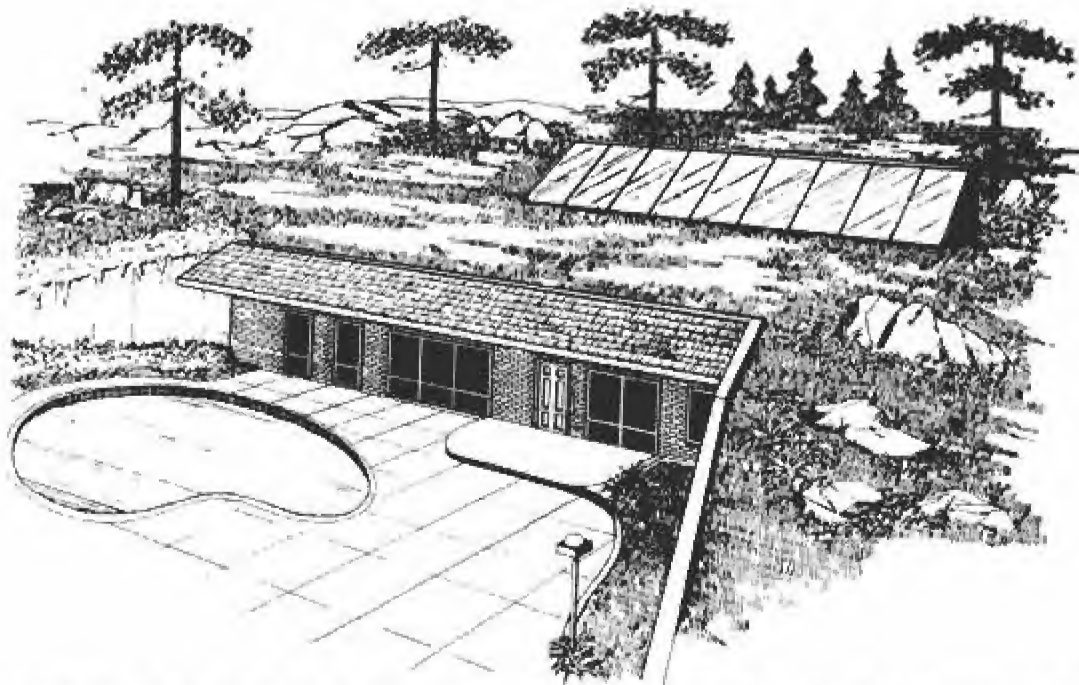
But already we have heard rumors about new, sophisticated coding schemes. And here's something to ponder: *The Locksmith* will not copy itself.

But the real solution must lie in an as-yet-unfound way to protect software from being copied indiscriminately—without detracting from its reliability and usability. The fellow who solves this problem will make a fortune.





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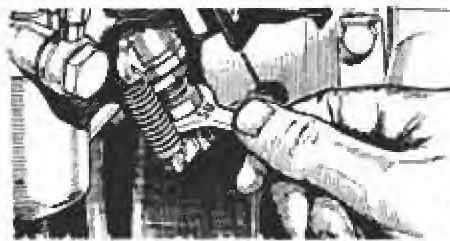
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| 1145 | DODGE 55-71 inc Coronet, Monaco, Polara                    | \$12.95 |
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| 8371 | DODGE PICKUPS 65-78 covers all 4-wheel drive models        | \$9.95  |
| 1298 | DODGE PICKUPS 71-79 covers all models                      | \$10.95 |
| 6203 | DODGE VANS 67-70 at 1, 2, & 3 ton models inc Plymouth      | \$9.95  |
| 6070 | DODGE VANS 71-79 covers all models                         | \$10.95 |
| 8197 | DUSTER 70-76 for all models inc 1000                       | \$9.95  |
| 8189 | FAIRLARK, FORD 67-70 covers all models                     | \$9.95  |
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| 9477 | FALCON 60-64 covers all models inc Mercury Comet           | \$9.95  |
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| 0451 | FORD PICKUP 69-79 covers all models                        | \$10.95 |
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| 0885 | HONDA ACCORD 77-79 covers all models                       | \$10.95 |
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| 8565 | INTERNATIONAL 62-78 truck, medium truck, wagon, pickup     | \$9.95  |
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## EPA MILEAGE FIGURES

(Continued from page 68)

average speed of 15 mph. The results are shown in Chart 1.

I then ran three separate cruising tests on the expressway, going against the wind. See Chart 2.

In every case, fuel economy *exceeded* the EPA estimate for the 1979 Ford Granada. On the average, I attained 19.48 mpg. This is 3.48 mpg, or 20 percent, greater than the EPA estimate. It was achieved, I believe, because vehicle speed was held constant, and there was no acceleration factor. Wind resistance didn't seem to play as much of a role as I had anticipated. The average mileage with wind was 19.67 mpg. The average mileage against wind was 19.3 mpg.

3. I conducted acceleration tests, as follows:

■ I ran three tests at wide open throttle from a dead stop to 55 mph by flooring the accelerator pedal. The distance covered during each test was approximately 0.1 mile. The average amount of fuel used was .0275 gallon, equivalent to 3.6 mpg.

■ I ran three tests at moderate throttle from a dead stop to 55 mph. The distance covered during each

test was approximately 0.2 mile. The average amount of fuel used was .0273 gallon, equivalent to 7.3 mpg.

■ I ran three tests at light throttle from a dead stop to 55 mph. The distance covered during each test was approximately 0.35 mile. The average amount of fuel consumed was .0316 gallon, equivalent to 11 mpg.

An engine consumes the greatest amount of fuel accelerating. The PM correction factor is figured on the basis of a light foot, that is, *accelerating at a maximum speed of three miles per second*.

A very light throttle foot isn't the answer for everyone, however. (See "Fresh Start," *Tech Front Lines*, page 130.) If you have a manual transmission and fuel injection, it might be more efficient to use a heavier foot on the throttle. The key, whether with manual or automatic, is to attain speed as fast as possible without getting into your carburetor's power enrichment circuit.

4. I conducted two separate tests in downtown Ann Arbor (heavy traffic). The first test covered three miles at an average speed of 13.7 mph. The car consumed .2576 gallon of fuel, equivalent to 11.6 mpg.

The second test covered a distance of three miles at an average speed of

14 mph. The car consumed .2682 gallon of fuel, equivalent to 11.2 mpg.

No doubt, city driving hurts fuel economy. In six miles of slow, stop-go traffic, the Granada averaged 11.4 mpg. This is 4.6 mpg (40 percent) less than the EPA estimate.

■ Taking all data I gathered into consideration, I have come up with the following: If you drive mostly in the city, use a 40 percent correction factor. Thus, if a car is EPA rated at 23 mpg, assume you will get 40 percent *less* mileage, or 13.8 mpg.

■ If you drive only on the highway, where traffic never ties you up, estimate your mileage as 15 percent *greater* than the EPA estimate. Thus, if the EPA estimate tells you your car will get 25 mpg, figure it will get 29 mpg. The 15 percent correction factor makes allowance for starting and driving a car that has a cold engine until it's warmed up.

This assumes certain conditions:

First, that you use a light foot on the pedal to accelerate. Second, that you maintain a speed close to the legal speed limit. I didn't run tests above the speed limit. The last factor to consider is ambient air temperature. Generally, the colder the temperature, the lower the mileage you can expect.

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# LETTERS

(Continued from page 76)

## Look-alikes not the same

The article *21 Exciting New Sports Planes You Can Build* (page 74, Jan. '81) contained an unfortunate error. The canard ultralight depicted in a photo as the Ibis is, in fact, a Goldwing. The Goldwing has a 65-mph cruise speed and a fuel economy in excess of 50 mpg. A free information sheet and a \$6 information package are available from Goldwing Ltd., Box 1123, Jackson, Calif. 95642.

BRIAN GLENN  
GOLDWING LTD.  
JACKSON, CALIF.

*The Goldwing and Ibis are very similar in appearance and were both photographed on the same day at the last Oshkosh Fly-in. The labels on the two were transposed in the dark-room.*

## Car Clinic cuts costs

My 1978 Catalina started knocking badly. I changed brands of gasoline and finally went to premium—with no help. It still knocked.

Then I opened my Feb. '80 issue of PM and there in your *Car Clinic* column (page 52) was the answer—a stuck flap valve in the air-cleaner snorkel. No more knocking. Thanks to you, I saved a trip to the garage and a bundle of bucks.

EDWIN J. JACKSON  
ORMOND BEACH, FLA.

I look forward to *Car Clinic* every month. I can't understand why many dealers aren't aware of the service bulletins you mention.

ALAN M. MASTERSON  
SAN LEANDRO, CALIF.

*If you like our Car Clinic, you'll love our annual Car Care Guide. It begins on page 133.*

## Caught speeding

It's a shame that tape cassettes don't operate at a faster speed than 1 1/2 inches per second. However, the 19 i.p.s. you claim in your article *Cassette Decks: New Ways to Sound Good* (page 78, Feb. '81) is a little extreme. At that speed, a C-60 cassette would hold only three minutes of music per side!

FRANK GENTRY  
DALLAS

*Our experts do know better. The error occurred during final printing. We'll pay the fine.*

PM

# LIGHT UP YOUR LIFE.



The Honda EM-500 portable generator can light up your campsite without weighing you down. It gives you up to 500 (max.) watts of power in a lightweight 40 lb. package. And it's as compact as a small, portable T.V. The EM-500 starts

easily, runs quietly and needs no fuel pre-mixing.

To find the Honda Generator dealer nearest you, just look in the Yellow Pages, or call toll-free 800-228-2056, ext 640. In Nebraska, 402-571-4900, ext 640.

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100's, 9 mg. "tar", 0.7 mg. nicotine av. per cigarette. FTC Report Jan. '80.

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With low tar Belair

only 9mg. tar



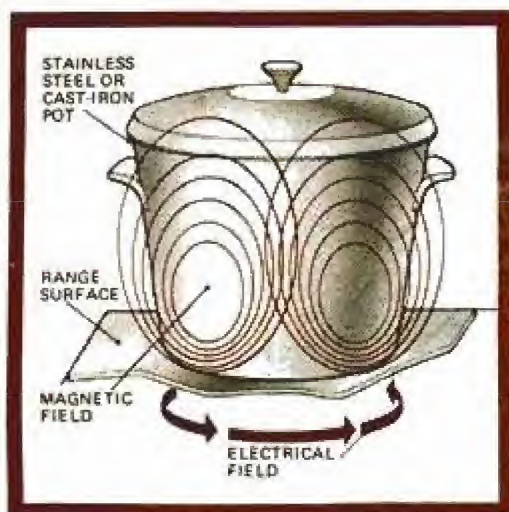
Warning: The Surgeon General Has Determined  
That Cigarette Smoking Is Dangerous to Your Health.



# Cool new ways to cook with less fuel

Today's appliances cook faster and safer while conserving energy—and they prepare food better than ever.

by John H. Ingersoll



Magnetic field flows from the electric field to generate an electron flow. Ferrous metals resist flow and produce heat.

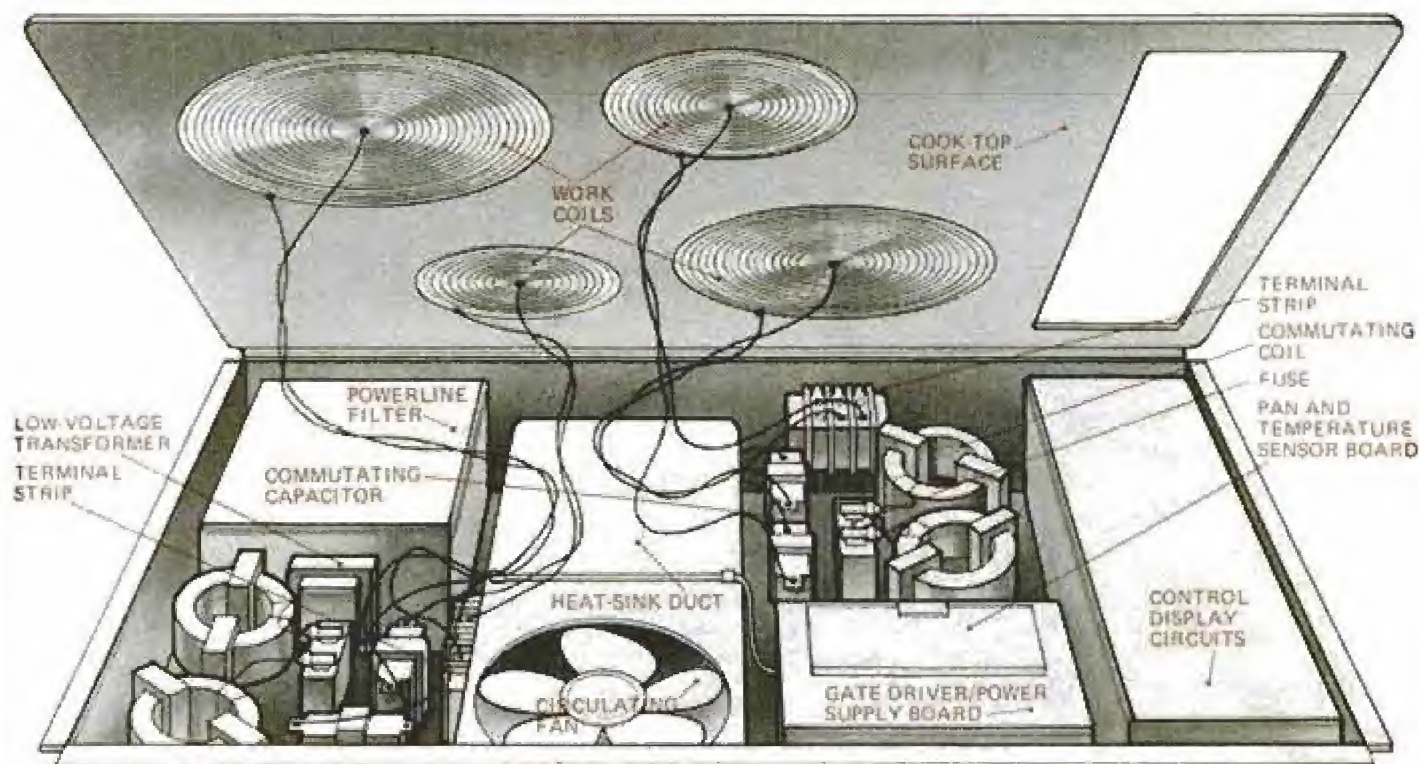


Glass cooktop of this induction range by Chambers Corp., Oxford, Miss., is only warm to the touch. Drawing (below) shows range's power and heat-distribution system.

Cooking has taken another big electronic step into the future—the development of the induction range. Brought out experimentally in 1972, this microprocessor-controlled wonder went into production last year. Today, Chambers, Roper and Fasar offer induction-range models. By the end of this month, General Electric expects to market its version.

For a sum between \$1,200 and \$2,000, an induction range can be yours. You'll get a power circuit setting up a magnetic field that induces a ferrous metal pot to cook your favorite spaghetti sauce as slowly (or as fast) as you wish, evenly with absolutely no hot spots, and using less energy than a gas or conventional electric range.

The pot, not the cooking coil, heats





the food. Some further advantages are: shorter heat-up time—shorter even than a gas flame; a relatively cool monolithic glass (or ceramic) cooktop on which spills wipe up easily and you can't burn your hand; instant reaction of the pot to shift from boil to simmer.

An induction range operates from a 220-240-v. outlet which flows to a transformer. The current, converted to d.c. and pushed up to 30,000 cycles per second, spins into the work coil on the underside of the cooktop, producing a magnetic field that cuts across a metal cookpot. The electromagnetic energy of the magnetic field is converted to kinetic energy within the metal and this in turn, is transformed into heat. This heat simmers the spaghetti sauce.

Since nickel-chrome steel puts up maximum resistance to electron flow, it is the first choice for pots and pans used on an induction range. Next is ferro-magnetic steel. Porcelain-covered steel pots will also work. Cast iron is okay, but it heats more slowly.

All-copper or all-aluminum pots barely get warm, since both metals are such good electrical conductors; they offer little heat-producing resistance. Glass or ceramic pots are useless on the cooktop.

Induction ranges save energy in several ways. Their fast start-up conserves power. And only the pot heats. Just think of placing a 4-in.-dia. pot on a standard electric burner. Half of the burner just heats air. On an induction range, only the pot absorbs heat.

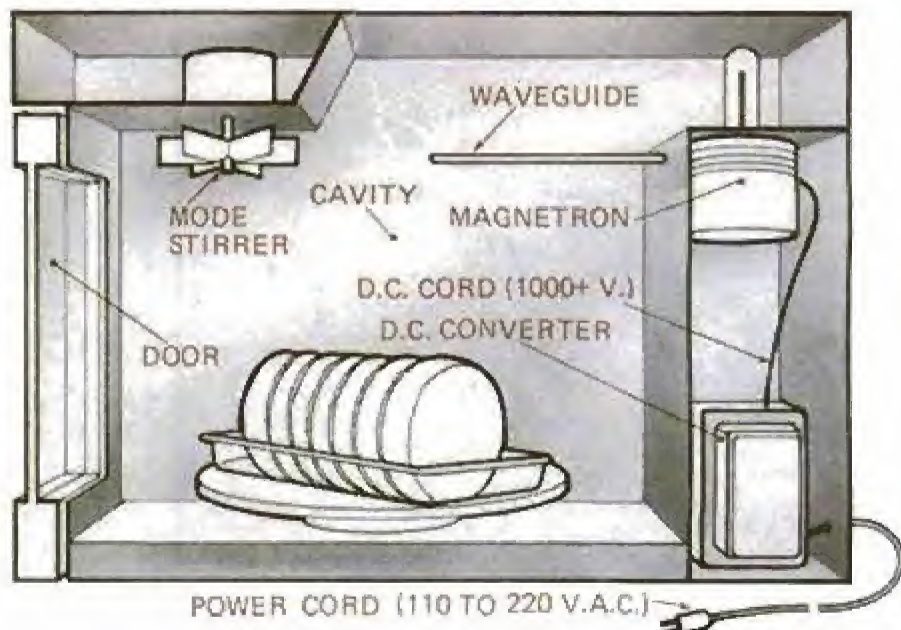
When water boils away in a pot on an induction range, the pot begins to overheat and warms the cooktop. This signals a relay that snaps off power. Also, if you lift a pot from the cooktop while power is on, the magnetic field automatically ceases.

Induction ranges have the potential of saving up to 40 percent of the power an electric range consumes. They can save 35 percent over a gas range.

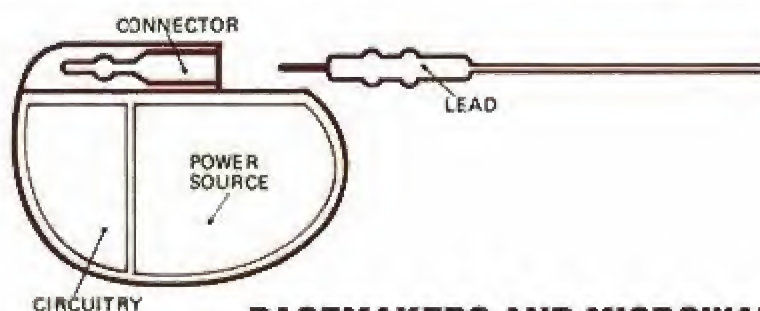
New microwave ovens, on the other hand, have improved features, and their prices are lower than ever. Countertop models able to take a medium-size turkey sell below \$500 in many cases.

Several improvements have been made on the newer models:

- Food cooks evenly in the new ovens. In older models, it was possible for part of a rolled roast to come out barely warm, while another part was tough and overdone because microwaves bounced off the metal sides of the cavity in an uncontrolled pattern.



Drawing (top) shows basic format of a microwave oven. View inside the Sharp microwave-convection oven (above) shows circular rack that rotates to cook the food evenly.



## PACEMAKERS AND MICROWAVES

"A dozen or so years ago, the first pacemakers could be interrupted by stray waves from microwave ovens, or car ignitions, or a malfunctioning TV tube," says Dr. Don Justesen, director, VA Hospital, Kansas City, Mo., and a leading cardiac specialist. "That's not true today for two reasons."

He explains that pacemaker manufacturers quickly developed shielding

for the delicate mechanism within a pacemaker. The shielding is metal—titanium or high-grade stainless steel. The metal encapsulates the device. Microwaves bounce off the metal, just as they reflect from metal in an oven.

As a second precaution, the makers put a filter where the wire enters the pacemaker. This filter stops stray waves from flowing downward.—J.J.



Today, ovens have microwave "stirrers" that look like small fans (see drawing on page 88). The spinning stirrers catch microwaves flowing from the magnetron and disperse them in a reasonably even pattern to all points of the cavity. In addition, most ovens now have rotating food racks for food, or you can get them as accessories. The racks slowly turn as the food cooks, further reducing the chance of cold spots.

■ New ovens, combining convection and microwave cooking, brown meat and turn cakes a golden color, the same as in a conventional oven.

Are the new models safe? "Worrying over injuries from microwaves in an oven is like being afraid of get-

ting trampled to death by an ant," says Robert F. Schiffman, president of the International Microwave Power Institute. Microwaves don't emit ionizing radiation, as do X-rays. Microwaves are in the same class as waves from radios, toasters, infrared heaters and the sun.

Microwave ovens sold in the United States exceed strict government standards for emissions (no more than 1 milliwatt per square centimeter at a distance of 5 centimeters from the oven). By comparison, summer sun delivers about 100 mw. per sq. cm.

"No injuries have been reported from microwaves in an oven during an estimated 100,000,000 hours of use over the past 20 years," reports

Guenther Baumgart, president of the Association of Home Appliance Manufacturers.

Energy and time are conserved by microwave cooking because of its speed. In a microwave oven, a potato takes four to six minutes to cook; in a conventional oven, 45 minutes.

In a conventional oven, cooking a potato burns up 1.16 kilowatt-hours; in a microwave oven, .43 kwh. or 63 percent less. Savings vary with food.

Convection ovens are air movers. A fan or fans at the rear of the cavity circulate heated air around the food. About 90 percent of the air is recirculated; 10 percent is vented and replaced with fresh air for combustion (in gas units).

Two features of a convection oven



Both standard and convection cooking are possible in the model CTCO-300 by Moulinex. It has two shelves for full-meal capacity and a rotisserie to allow self-basting.



Sanyo offers a combination gas convection-microwave oven. It comes in a countertop model that sells for \$870.

Electric-convection and microwave cooking combine in new Radarange by Amana. It is powered by a 120-v. line. The price is around \$850.



Placed in Amana microwave oven, \$30 Amana corn popper yields two to three quarts of popcorn. You needn't add oil or shake the popper.



General Electric's new Spacemaker microwave oven has a humidity sensor that judges cooking progress and regulates time and power level.



improve cooking quality: First, slowly circulating air cooks food more evenly. Second, moving air disturbs a layer of insulating air over the food, so heat penetrates directly.

Because of this direct heat penetration, food cooks faster at much lower temperatures.

Using gas as fuel, a convection oven saves 10 to 15 percent of the gas required to cook conventionally. Very little, if any, energy is saved in an electric convection oven.

Research in the '50s and '60s brought us microwave cooking. You can count on research in the '80s to tie microprocessors more closely to our cooking habits. **FM**

Four-burner gas range and gas convection oven with two fans combine with microwave capability in Caloric unit (\$1350).



Revere promises nonstick cooking in its stainless-steel skillets lined in DuPont's SilverStone; 10-in. pan costs \$30.

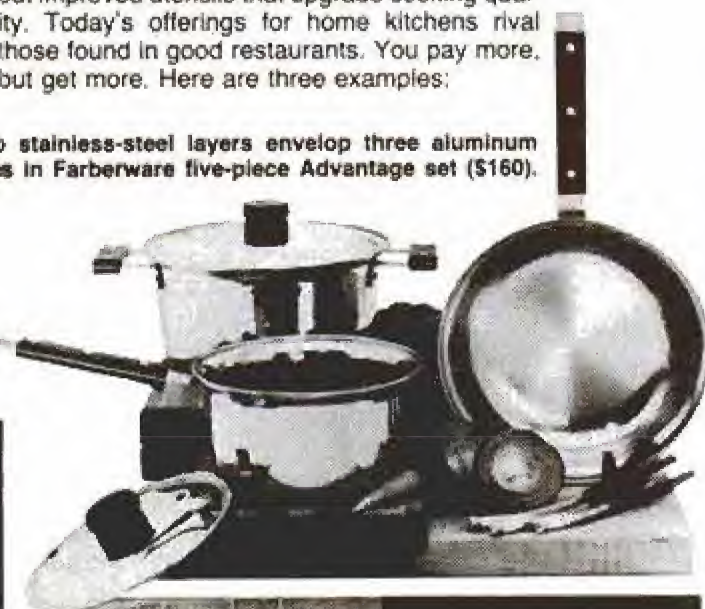


In a convection oven (above), the heated air is drawn across the top of the food, around the sides and under the bottom to cook evenly.

## NEW POTS THAT PAN OUT

Appliances aren't the only new advances in the kitchen. Pot and pan makers have been turning out improved utensils that upgrade cooking quality. Today's offerings for home kitchens rival those found in good restaurants. You pay more, but get more. Here are three examples:

Two stainless-steel layers envelop three aluminum ones in Farberware five-piece Advantage set (\$160).

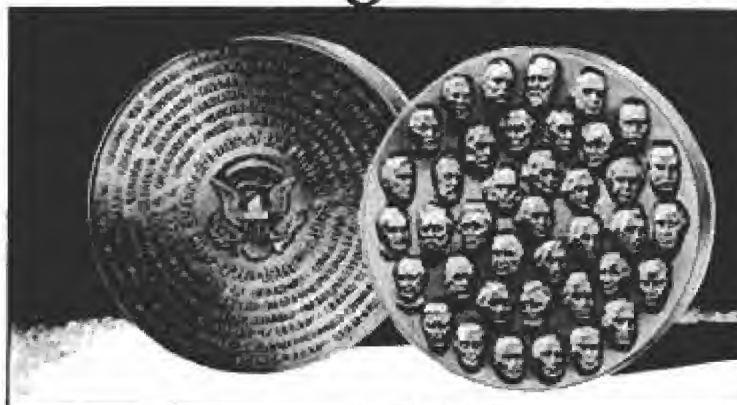


Made to last a lifetime, Mirro's hard anodized aluminum pots are called Classic Chefware. An 8-liter pot costs \$63.



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Each of these unique mini-struck "COLLECTIBLES" will be placed in our unique collector's display case and is accompanied by our serial numbered Certificate of Authenticity certifying to the provenance of each coin as an original die-struck minting and that it has been electroplated with **PURE 24 KARAT GOLD.** Furthermore, it assures you of receiving a coin as an original die-struck minting and that it has been electroplated with **PURE 24 KARAT GOLD.** Furthermore, it assures you of receiving a coin that will never again be minted after January 20, 1982 (Exactly one year from the historic date of President Reagan's inauguration). This means that unless you order within the **LIMITED OFFER PERIOD**, your only chance of owning the coin would be through dealers, collectors or at private auctions at whatever price the market might bear.

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Many people like yourself desire lower serial numbers. The serial number you receive will be determined by the date we receive your order. Of course, lowest assigned serial numbers are always shipped first. This is especially important if you intend to order several "President's Coins" to save or pass on to your family and friends as gifts and treasured family heirlooms.

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| ***** VITAL COLLECTOR'S STATISTIC ***** |  |
|---|--|
| SIZE:                                   | 39 mm (larger than a silver dollar)  |
| FRONT SIDE:                             | Sculptured, raised-relief busts of all 39 U.S. Presidents  |
| REVERSE SIDE:                           | All 39 names in "raised monument 'chiseled' letters in circular rows around an American Eagle Seal   |
| DATE OF MINTAGE:                        | Jan. 20, 1981 - Jan. 20, 1982  |
| DURATION OF MINTAGE:                    | Will never again be minted or made available after Jan. 20, 1982 (one year from President Reagan's inauguration). Dies scheduled for destruction on that date. |
| METHOD OF MINTAGE:                      | Double Die Struck in solid bronze then electroplated with <b>GENUINE 24 KARAT GOLD</b>   |

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# HOMEOWNERS' CLINIC

## QUESTIONS ANSWERED

### Condensation woe

*I'm a do-it-yourself carpenter (three houses and one remodeling job). My latest house is trimmed in oak, and it has aluminum windows. It's built tight and is energy-efficient, with heat pump, wood stove and adequate insulation. The problem is that the aluminum window frames sweat throughout the night and the oak trim is being ruined by the moisture. In these days of airtight homes, someone must have the answer. Any help would be appreciated.*—Charles B. Pearman, Port Angeles, Wash.

For now, your help comes in the form of storm windows. These, of course, create an airspace between window and storm window. This allows the innermost glass and interior frame surface to approach room temperature. The problem is that the warm, moist air inside the house hits the cold aluminum, causing condensation. Before purchasing a dehumidifier, borrow one to see if it reduces the problem. If it does, that would be cheaper than storm windows.

For your information, though, new developments in aluminum frames make them less prone to moisture condensation. The Architectural Aluminum Manufacturers Assn. (AAMA) states that windows are now being "thermally broken," usually by pieces of vinyl. This means that instead of the frames being in one piece, they are now constructed of two or three extrusions, separated by the vinyl or similar insulating material. Thus, the aluminum exposed to the cold exterior is not the same piece that is exposed to the warm interior—therefore, no sweat.

Keep in mind, however, before you blame all your woes on the aluminum, that single-pane glass can cause even greater condensation. Storm windows will help in both cases.

### Cracked walls

*My old, but well-built, house has cracks in the plastered walls. In some rooms, they are worse than in others. What is the best quality paint I can use to keep the cracks from recurring? I might be able to afford the material, but I'd have to do the job myself. I want the treatment to last, so I will need lots of advice. I'd probably start on my smallest room.*—Madelyne Winkelman, Wichita, Kan.

Madelyne, paint's not your answer, no matter how good it is, or how thickly you apply it. "Kitchen Ceiling Cracks" (*Homeowners' Clinic*, page 126, Jan. '79) outlines a method for repairing cracks. However, if you've tried this and the cracks keep recurring, you might want to try a lining stock that comes in rolls similar to wallpaper. It's made to cover cracked and rough walls. In fact, the manufacturer claims that it



Wall Cover gives smooth surface to cement block and other rough walls. Then you can cover walls with paint or wallpaper.

can be applied over block and brick as a base that you can cover with a smooth-finish material, such as wallpaper. The product is a fiber-cellulose-acrylic composition called Wall Cover. You install it with a ready-mix vinyl adhesive, in much the same fashion as you install conventional wall coverings. Wall Cover is available in 28- and 48-in. widths; it costs about \$8 per 36 sq. ft.

Although the manufacturer claims success with installations over wood paneling, it will not guarantee such installations due to varying degrees of climatic conditions and wood finishes.

If your local paint and wallpaper

store doesn't stock Wall Cover, write to Imperial Wallcoverings, 23645 Mercantile Rd., Cleveland, Ohio 44122, for the name of the supplier nearest you.

### Wooden coal bin

*I'm building an all-weather wood foundation for my new home in Alaska. I want to build a coal bin in the basement. How can I best protect it from any fire hazard?*—Judith A. Hudok, Anchorage, Alaska

I don't believe that your situation should be any more of a fire hazard than smoking a cigaret in a wood-paneled, concrete-block basement. Heavy-timbered construction (such as 4x6s or larger) with the corners slightly chamfered, qualifies as slow-burning construction. (Sharp corners cause easier ignition.) Think of it as trying to ignite a 6-in.-round log with a match, as opposed to igniting a 1/2-in.-sq. stick with a match.

### Losing face

*The bricks on my 22-year-old chimney have been spalling off in chunks. I've glued the chunks back with epoxy, but then they flake off on a different plane. How can I prevent the other bricks from losing their top surface? How can I make permanent repairs?*—Richard Merakin, Worcester, Mass.

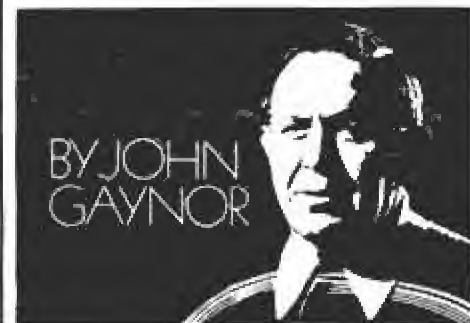
The Brick Institute feels that you undoubtedly have some improperly fired or porous bricks. Rain and moisture get into these pores and this water freezes when the temperature drops. This causes the brick to crack and flake off.

Your photo doesn't indicate an abundance of bricks, so I'd suggest replacing the affected bricks with new ones. Then seal the chimney with a commercial masonry sealer.

As a last resort, a neighbor of mine had felt and metal lath installed over the entire chimney. Then a plasterer topped this with a 1/2-in. thickness of stucco.

PM

Do you have a home maintenance or repair problem? Send it to Homeowners' Clinic, Popular Mechanics, 224 West 57th St., New York, N.Y. 10019. Letters cannot be answered individually, but problems of wide interest will be discussed in this column. For more home repair and maintenance help, get PM's Home Care Guide, \$4.95 postpaid. Send order(s) to PM, Dept. HCG, Box 1014, New York, N.Y. 10019.





# "Save some money on your homeowners insurance and get some peace of mind, too."

State Farm agent Chuck Thulin, Boulder, Colorado. "If you've been thinking of taking extra measures to protect your home and family against fire, burglary and vandalism, State Farm agents are offering some encouragement.

"If you install deadbolt locks, a smoke alarm and a fire extinguisher, we'll take 5% off your homeowners insurance premium. It's all part of State Farm's Home Alert Program."

"We'll save you some money on your homeowners insurance, if you'll take the steps that may save something a lot more important. Check your Yellow Pages and call the State Farm agent nearest you."

\*Available in most states.



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PM



Chatiemac model log home (shown above) is one of 15 do-it-yourself models that's available.

Stack-and-build system uses hand-crafted joints and hand-notched corners that add to both the good looks and strength of the house.



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# Homeowner Drills His Own Backyard Water Well

A tip from his wife turned into a money-saving hobby.

Interview with Capt. Charles Anders, Airline Pilot

I'm Rex Roach, Factory Sales Manager of DeepRock Mfg. Co. Today I'm talking with Capt. C.H. Anders of Atlanta, Ga. who who is an airline pilot. Capt. Anders, you purchased a Hydra-Drill about 3 months ago. Are you having pretty good luck?

A. Yes, I haven't drilled a well yet that I didn't hit water, so I consider that pretty good luck.

Q. Capt. Anders, what made you decide to drill your own well? Why not hire a commercial driller?

A. I had planned to do that, then my wife saw this ad about the Hydra-Drill and how you can drill your own well. She was kidding me about it because I had told her how I helped dig a well when I was a boy. But I got the literature and it was so interesting I decided to order one.

Q. How many wells have you drilled?

A. Four — actually, I'm drilling the fourth now, and it looks very promising. I'm already down about 75 feet, and I'll probably go another 30 or 40 feet. I expect to get about 600 gallons of water per hour at that depth.

Q. Is that good?

A. Around here, it sure is. Some of my neighbors hired commercial drillers and got about 300 gallons per hour.

Q. That's a lot of water. Why do you need more?

A. Well, for irrigation — you



know, flowers and sprinkling the lawn and things like that. This is a dry area. We just don't get a lot of rain like other parts of Georgia. In fact, we've really had a drought here for over a year, and a lot of people have had a well drilled recently.

Q. But you had never drilled a well before?

A. No, but I saw how simple it is. It's really fascinating how this Hydra-Drill works. It's not

complicated, and it's very easy to operate. Anyone could do it.

Q. Could you drill a well by yourself?

A. Yeah, if my neighbors would let me. Every time I start drilling, they come drifting over wanting to help. It's more like fun than work and everybody wants to try it.

Q. What do your fellow pilots think about your well drilling?

A. At first they thought it was a joke. Then they came out and saw the green lawn and all the sprinklers going full blast — they tried to buy the Hydra-Drill from me. I had to promise to drill wells for a couple of them.

Q. It sounds like you are getting into the well drilling business.

A. Not really. I plan to keep flying for a long time. This drilling wells for friends is just a hobby, and I'm enjoying it. The Hydra-Drill has already paid for itself so I'm doing it just for the fun of it. It's really something to see that drill go down, and when that water starts flowing, you feel like you've really accomplished something.

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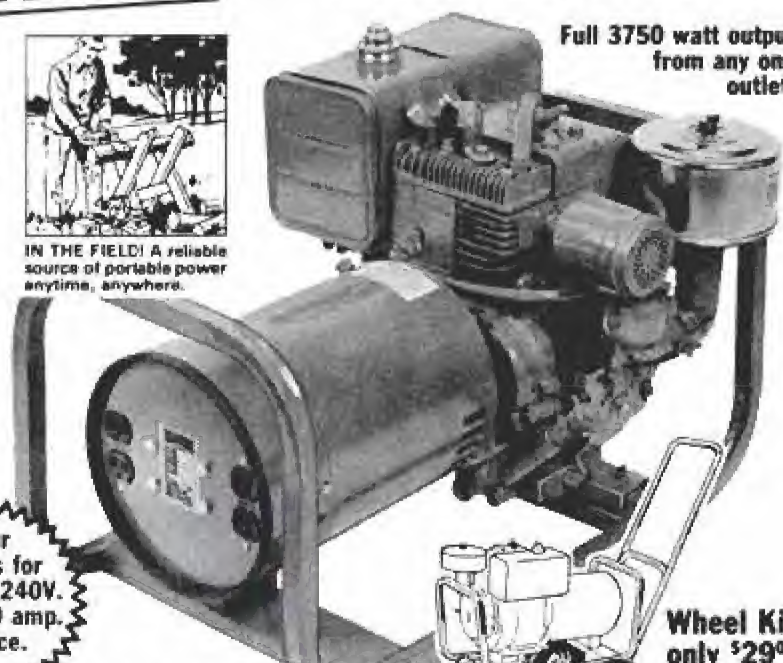
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# IS THE HAT TRICK GETTING EASIER AT INDY?

This year's field is crowded with more multiple winners than any field in history. Some say it's getting easier to win at the Brickyard.

by Pack Bryan

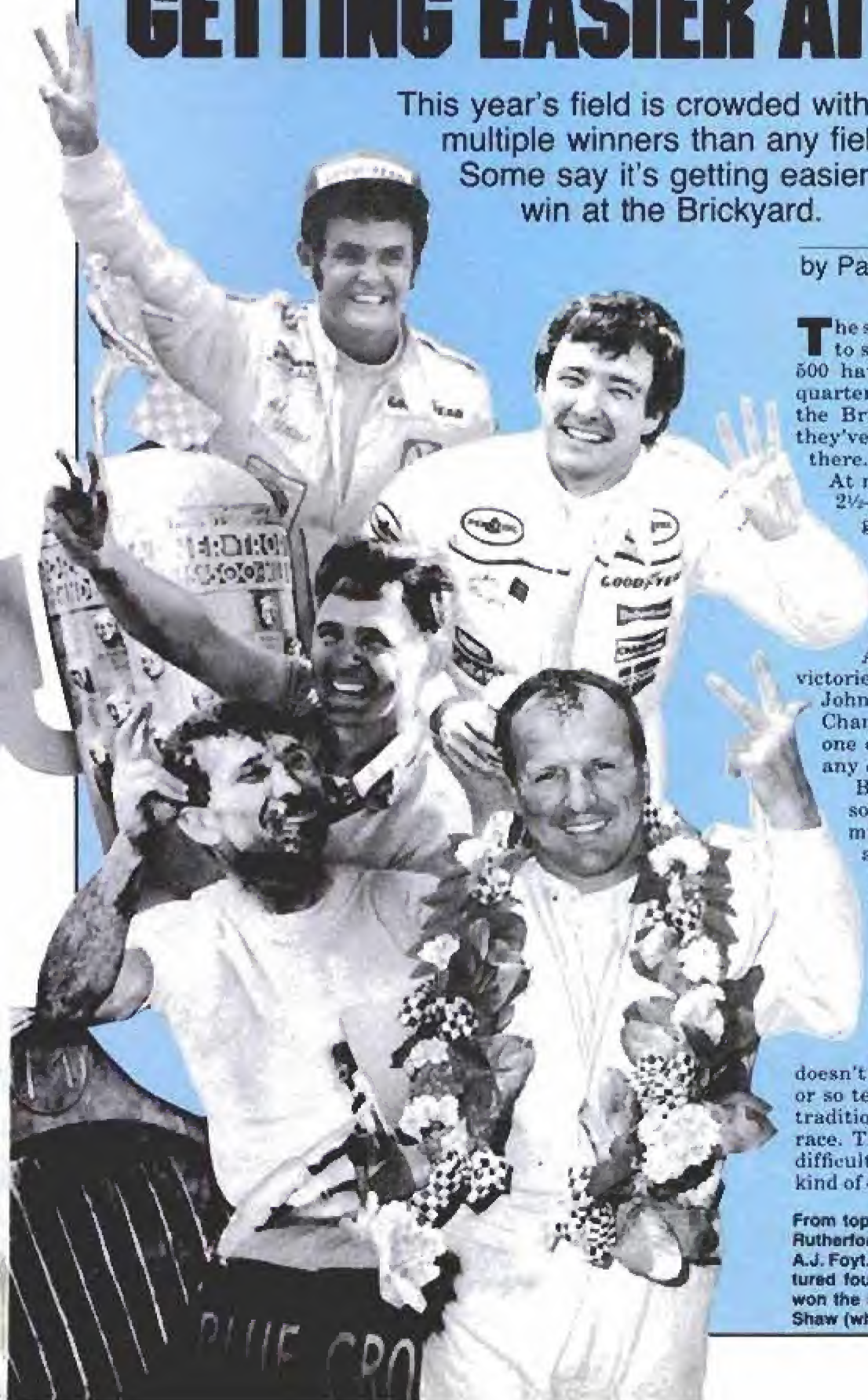
**T**he seven former winners eligible to start this year's Indianapolis 500 have, together, won almost a quarter of all the 500s ever run at the Brickyard. More significantly, they've won 15 of the last 20 races there.

At no time in the history of the 2½-mile oval has such a small group so completely dominated the competition. They are: A.J. Foyt, the only four-time winner; Al Unser and Johnny Rutherford, each with three wins; Al's brother Bobby, with two victories; and Rick Mears, Gordon Johncock and former World Champion Mario Andretti, with one each. Would you bet against any of them?

Betting on them will be sponsors who've invested close to \$3 million in equipment, salaries and expenses. All that for just one race and seven cars—14 cars, if you include the backup car each driver can count on. Either way, that's a lot of money, even with 1981's double-digit inflation.

When the favorites command the top dollars, it doesn't leave much for the other 50 or so teams shooting for one of the traditional 33 starting slots in the race. That's why it has become so difficult for newcomers to get the kind of equipment they need to com-

From top to bottom are Al Unser, Johnny Rutherford, Louis Meyer, Mauri Rose and A.J. Foyt. Foyt is the only man to have captured four Indy 500s. The rest have each won the 500 three times, including Wilbur Shaw (who is not pictured here).





# INDY OUTLAWS THE EXOTIC POWERPLANTS!

**H**ere we go again! For the umpteenth time in the 65-race history of the Indianapolis 500, there's been a change in the engine specifications. The new rules, effective for the 1982 race, limit participation to pushrod engines based on stock blocks, with normally aspirated engines limited to 355 cu. in. maximum, and turbocharged engines held to 209 inches.

Unlike previous changes, which merely gave an advantage to stock and stock-based engines, but permitted pure racing engines to compete, the new rules outlaw racing engines altogether. The new rules allegedly



Fuel Injection

give the "little guy" a better shot at making the 500 and, not so incidentally, trigger greater interest and participation by Detroit in open-wheel racing.

However, at a time when the industry is concentrating its effort on "getting more from less," with V6s, turbocharged Fours, and

even Threes, and moving away from the big V8s, it's strange to see Indy heading in the opposite direction.

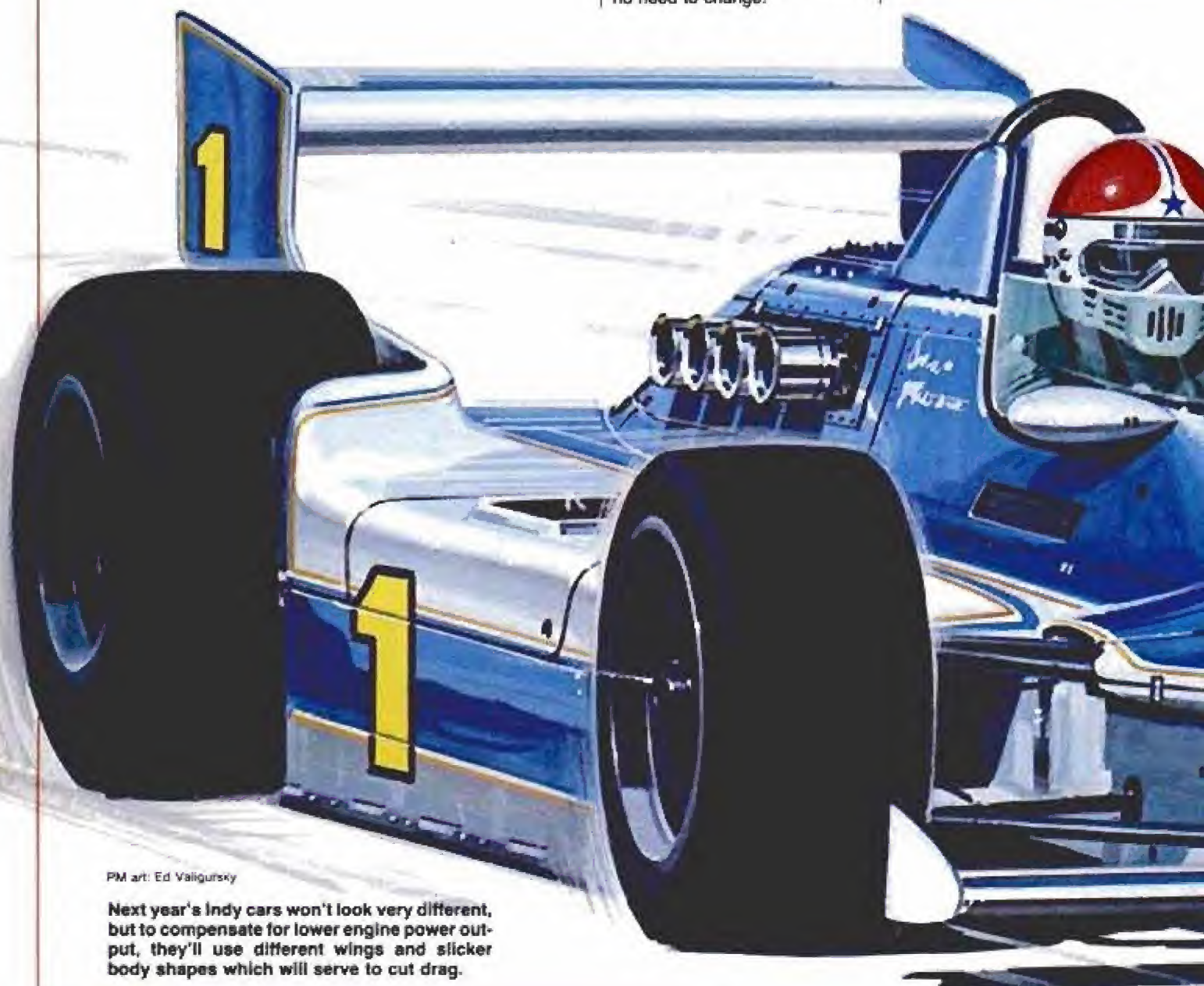
The difference between an exotic powerplant such as the Cosworth and a stock block is that the Cosworth has double-overhead cams and four valves per piston. The stock-based engines use pushrods and two valves per piston.

The 1980 winner, Johnny Rutherford, isn't happy about the switch, but has said, "We'll race with lawn-mower engines if we have to. It's the greatest race in the world, and we'll be there."

Like anyone doing well in his chosen field, Rutherford doesn't really want to see any changes. He says, "We've got the safest and strongest cars we've ever had in racing, right now. There's no need to change."

Gone are both the fixed and articulated skirts which helped to contain the partial vacuum that held the cars to the track. Gone, too, in 1982, will be "the engine that helped us set a record for continuous miles in competition, the Cosworth. We're being asked to give that up for an unknown, in the name of an

Four-bolt main bearings



PM art: Ed Valigursky

Next year's Indy cars won't look very different, but to compensate for lower engine power output, they'll use different wings and slicker body shapes which will serve to cut drag.





economy that probably isn't really there."

Reliability would go down drastically, Rutherford says, if the new rules were to go into effect immediately. With a year's development time, it should be less of a problem. "But costs will go up, too," he says. "If the engines are in demand, they'll simply cost more. But there's another factor that will have a great influence on costs—special parts."

The stock-based engines will be given greater stress than they encounter in any other kind of use, even greater than in NASCAR racing. So, a broad range of special parts, from rocker arms to connecting rods, bearings to specially made four-bolt main-bearing caps, will have to be designed and built. And once

you hang the word "special" on it, you'll pay plenty. It doesn't matter whether you're forging a connecting rod for a race engine or a stock-based race engine, the manufacturing costs will be about the same. But not the retail price.

If the racers find they can't make a stock-block engine durable enough, they'll be forced to buy special castings with beefed-up cylinder walls and more metal in the cylinder heads.

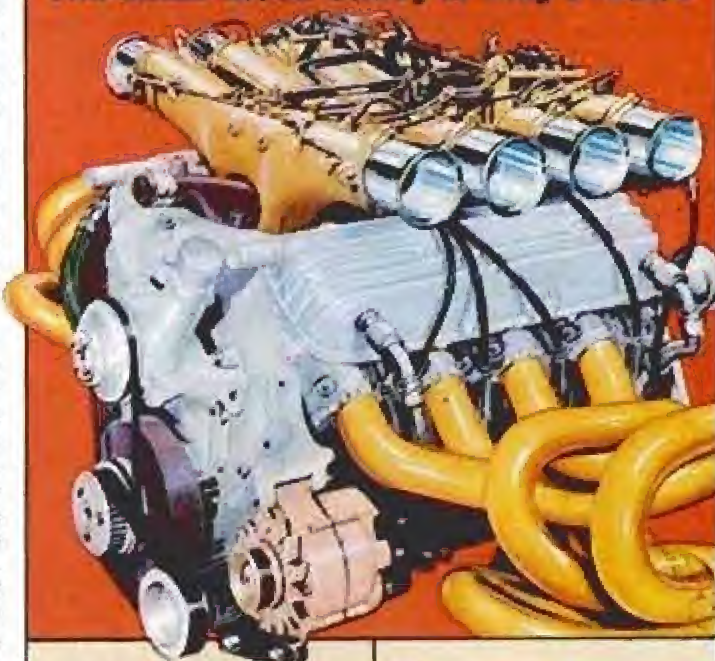
For instance, a racing small-block Chevy, which will undoubtedly be the engine of choice for most racers, will absolutely need to have four-bolt main-bearing caps to maintain bottom-end rigidity. The problem is that Chevy stopped making small-blocks with four-bolt mains due to the low-compression, low-horsepower yield of the current crop of VBs. Four-bolt mains simply haven't been necessary in these low-output engines.

The only alternative a racer has is to machine a two-bolt block to accept a four-bolt cap. That's a risky, and some say, a not very reliable thing to do. Or you can have a specialty casting shop cast a complete block with the desired traits—a very expensive proposition indeed.

For these reasons, some rac-

*(Please turn to page 227)*

## The small-block Chevy in Indy's future



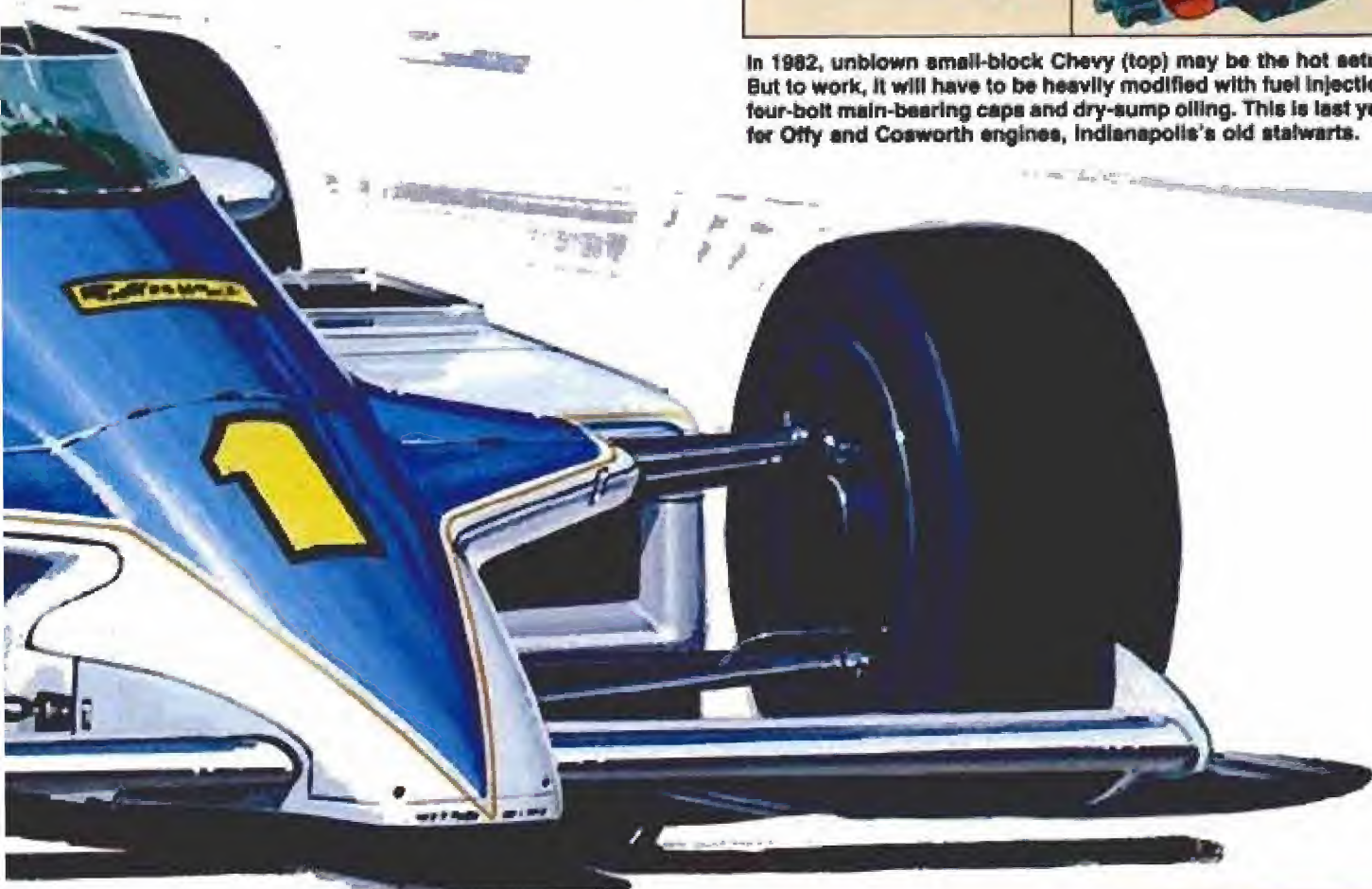
### The aging Offy



### The retired Cosworth



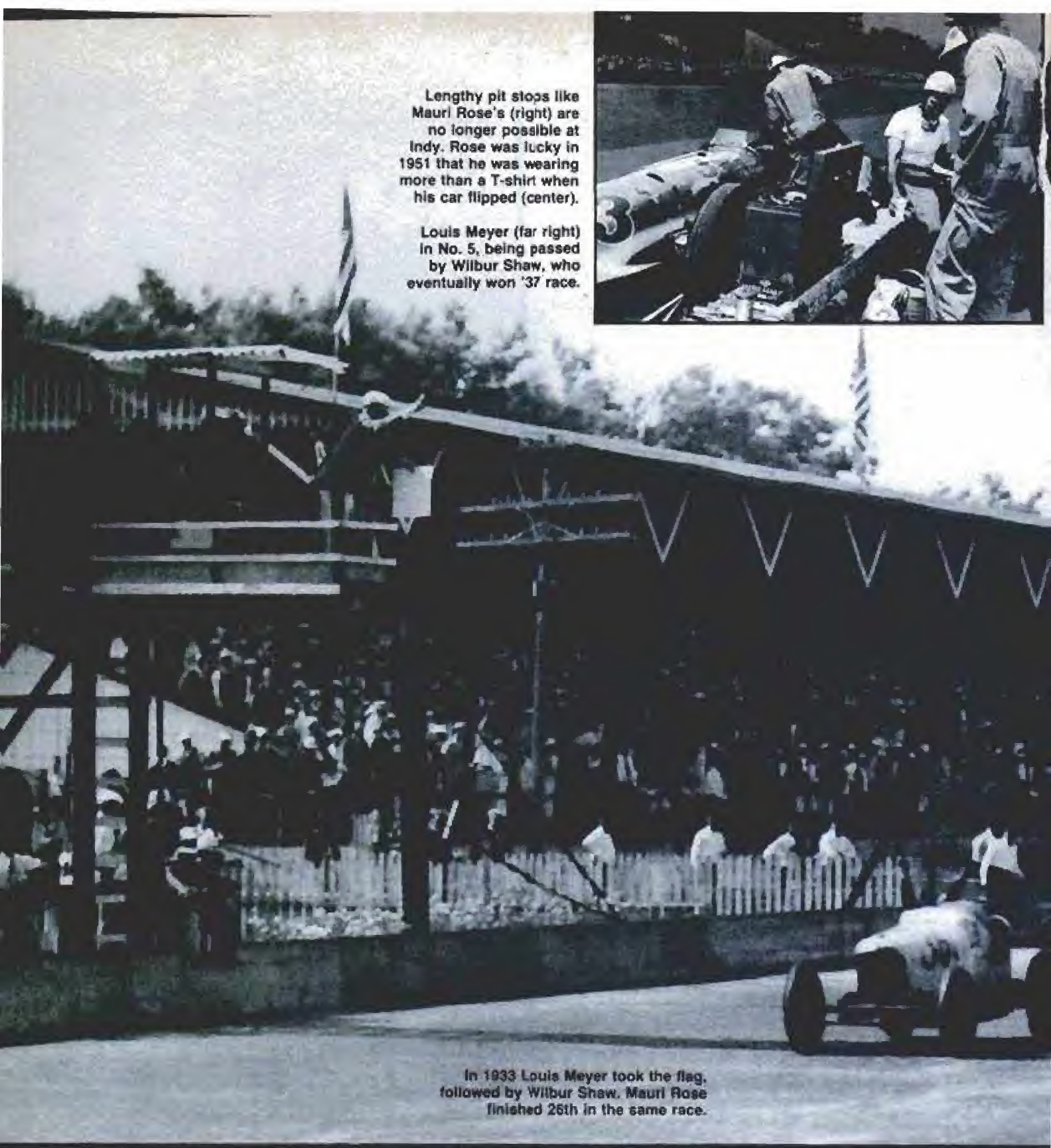
In 1982, unblown small-block Chevy (top) may be the hot setup. But to work, it will have to be heavily modified with fuel injection, four-bolt main-bearing caps and dry-sump oiling. This is last year for Offy and Cosworth engines, Indianapolis's old stalwarts.





Lengthy pit stops like Mauri Rose's (right) are no longer possible at Indy. Rose was lucky in 1951 that he was wearing more than a T-shirt when his car flipped (center).

Louis Meyer (far right) in No. 5, being passed by Wilbur Shaw, who eventually won '37 race.



In 1933 Louis Meyer took the flag, followed by Wilbur Shaw. Mauri Rose finished 26th in the same race.

pete successfully at Indianapolis.

That's also why there will be changes in the race's engine limitations as of 1982 (see previous page).

Unfortunately, the days of a "dark-horse" winner charging out of the pack to take the checkered flag at the end of 200 laps aren't likely to return—if they ever really existed. If you listen carefully to all the stories on which this legend is based, you'll notice that the "Indy-on-a-shoestring" boys never did better

than third. That in itself was a real achievement, but the name of the game is *winning*.

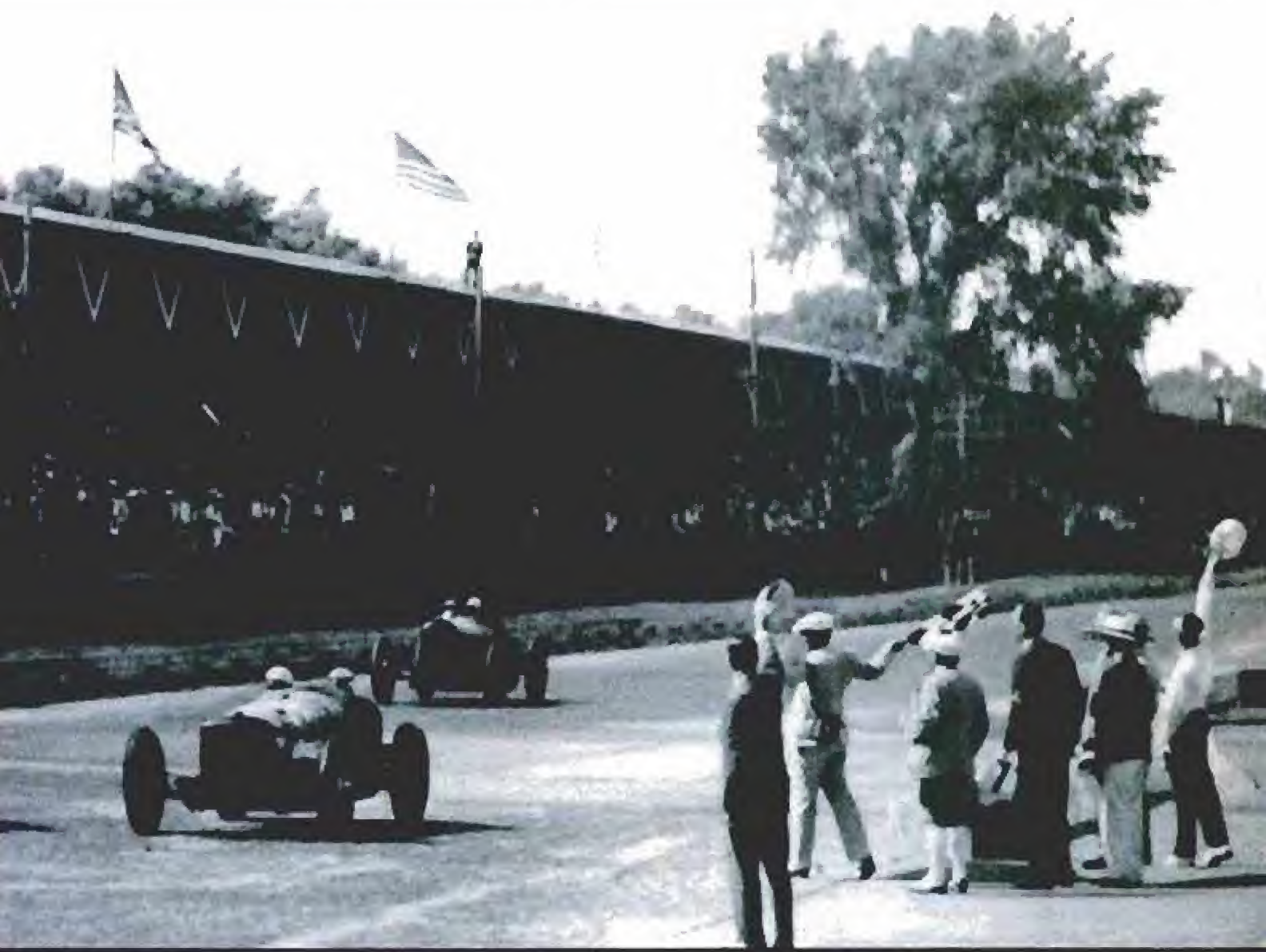
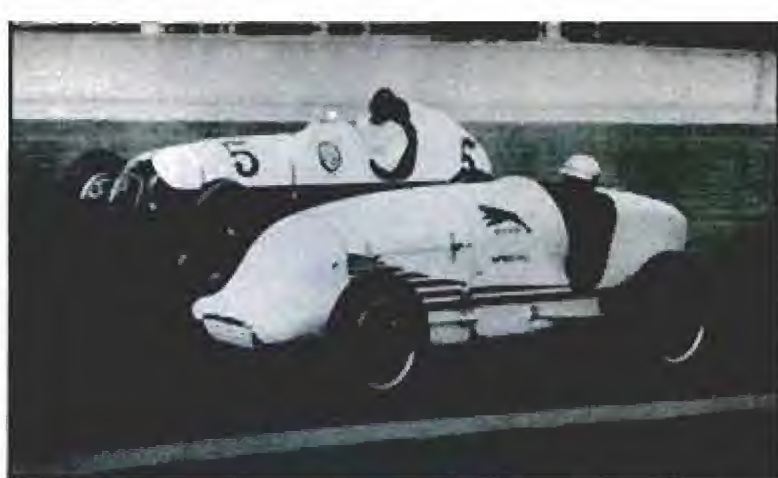
Even in the old days, when the first group of three-time winners began their climb to the top, racing was expensive. Louis Meyer's first 500 win, in 1928, was at the wheel of a Miller Special, powered by a supercharged eight-cylinder Miller engine of 90.2 cu. in. (bore was a tiny 2 1/4 inches and stroke was a long 3 inches even). The engine alone cost

\$15,000—in the days when a new Chrysler "Sedan Limousine" listed for \$3,495 and a Studebaker-built Rockne cost \$620!

#### The first stockers

In 1933, Meyer took the flag for a second time. He was driving another Miller Eight, this one of 258 cu. in. Despite the Speedway's earlier attempt in 1930 to cut the cost of racing, by upping limits to 366 cu. in. and giving stock entries all sorts of





advantages, the pure race engines continued to dominate by taking the first four places. But the stockers were catching up.

In 1931, a Buick-powered entry finished fifth, and then seven Studebakers followed each other across the line to take sixth through 12th places. That didn't quite match the best stocker effort ever—Cliff Bergere's 1932 third-place finish in a Studebaker.

Running against Meyer in that

race were two other drivers who'd eventually match his triple crown record: Mauri Rose, who finished fourth, and Wilbur Shaw, who took seventh. Although the three drivers ran against each other for many seasons, Meyer had retired by the time Shaw scored his hat trick and Shaw, in turn, had hung up his helmet before Rose won his third 500. By contrast, all three of the still-active three-time winners will be running in this year's race.

Wilbur Shaw placed an impressive fourth in his first race at Indianapolis in 1927, although he was relieved from laps 2 to 129 by another rookie, Louis Meyer. It took him eight more tries—with two second-place finishes—before he won in 1937. It was the last of the eight years during which the silly two-man-per-car rule was in effect.

Driving the streamlined Gilmore Special, powered with the relatively

*(Please turn to page 227)*





# RARE BIRD



Rotors' 25-foot diameters preclude airplane-type landings. Nacelles must tilt up to the 60° position.

Is it the world's fastest rotorcraft or just the most versatile airplane? Either way, it works.

**A**dvanced concepts in aerodynamics do not leap into the air overnight. Bell Helicopter (Textron Corp.) engineers have been flight-testing aircraft incorporating the "tilt-rotor" powerplant/wing format for the better part of three decades. With the XV-15, however, the idea appears to be hitting its stride at last. This aircraft achieved a speed of 301 knots (346 mph) last June, breaking an unofficial record for rotorcraft. The two extant models of the experimental craft are being tested by NASA and the military this year. Practical designs that evolve after this testing phase could have a

wide range of both civil and military applications.

Inflight operation of the unique aircraft is apparently far less hairy than it seems at first glance. Takeoffs can be made from a hover (in ground effect) to clear a 50-foot object in about 450 feet. Normal takeoff mode, however, has the nacelles set at 60° for a ground roll of about 950 feet, with 50-foot clearance in 1,440 feet. Once aloft, with 45 knots or more of airspeed, the pilot can "convert" to airplane-type flight in as little as 12 seconds.

Since the twin rotors are cross-coupled by a shaft through the wing, single-engine flight operation proceeds normally with reduced performance. In the event of total power failure, the nacelles are "reconverted"—it can even be done manually, like cranking down landing gear, in the absence of



# DOES IT ALL



hydraulic pressure—to a position that, at 95°, is slightly "backward" and allows an auto-rotation descent to an emergency landing with a final approach speed of about 50 knots. In the same emergency mode, the wings support a glide ratio of 10:1.

The relatively slow turning of the rotor blades—about 560 rpm in helicopter mode; some 100 less in airplane flight—makes for quiet operation with two Lycoming turbine engines that produce 2,800 hp together. Bell engineers say the XV-15 can fly over an urban area at 1,000 feet without being noticed—a feature that definitely enhances the future of tilt-rotor designs.

But it is the speed/economy advantage over conventional choppers that looms foremost in the tilt-rotor's favor. **PM**



Flight transition can be accomplished in 12 seconds; the pilot has a 70-knot "envelope" for the intermediate positions.



# Six new ways to get better sound from your stereo

New, ultrasophisticated electronic add-ons can turn your stereo into the next best thing to a concert hall.

by Neil Shapiro ELECTRONICS EDITOR

I thought I had heard it all, from low-fi to hi-fi—but I was wrong. No matter how good your present stereo system is, no matter how close you think it can take you to sonic never-never land, there are new devices that can expand, dimension and enhance your listening.

## From out of the labs

The devices we examined are based on two technological breakthroughs. The first is the realization that music is simply information; and information may be processed by computer-type circuitry. The second breakthrough is in new technologies to accomplish old goals better than before.

We examined six different types of units: expanders, digital delay, decoders, power supplies, imagers and holographers, and miniature headphones.

## Expanders

You come home from work and your wife greets you at the door with your favorite disc on the stereo. But no matter how excellent your system is, you know the music is prerecorded.

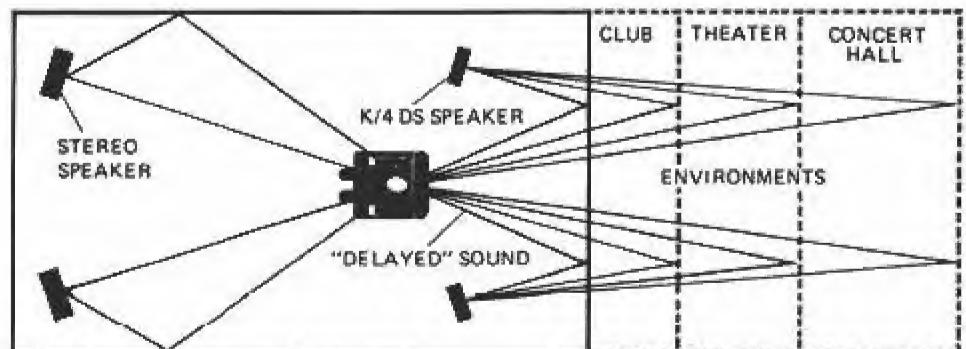
One reason that your ears aren't fooled is that music played back on a stereo lacks *dynamic range*. In a concert hall, the difference in sound between the loudest kettle drum and the softest triangle can vary by 100 decibels (dB).

But on a record, that difference between loud and soft would be only 70 dB; and on an FM broadcast of the same music, the difference would be just 50 dB. Increasing the volume wouldn't help because the softer sounds would get correspondingly louder as well. The tip-off to the ear is the *range* of loudness.

Enter the expander. We checked out two—the dbx 3BX (\$759) and the Pioneer RG-2 (\$195)—and both worked fine. Suddenly, soft passages were *really* soft and loud passages shook the roof.

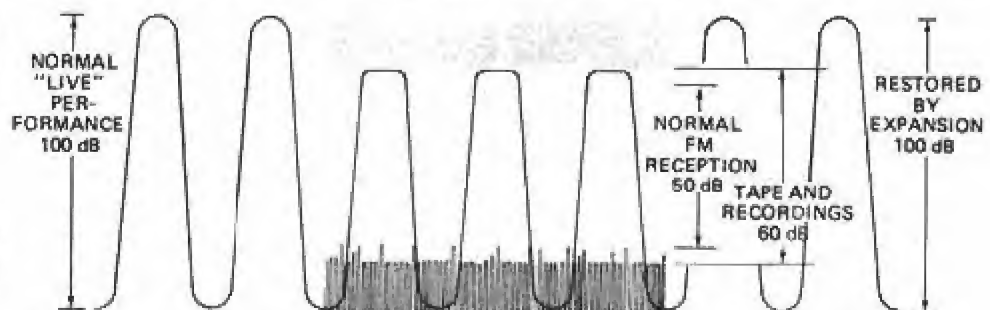
The dbx 3BX unit allows you to

(Please turn to page 230)



Digital delay system uses computer technology to simulate the "feel" of live music played in an acoustically responsive environment. Speakers behind the listener put

out processed sound that reproduces the way music would sound if it had been bouncing off, and interacting with, the walls of a larger room or concert hall.

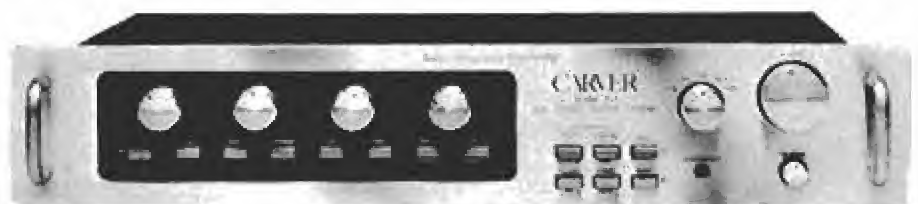


An expander restores the dynamic range to music. A sound range of 100 decibels is compressed by the electronic and mechanical squeezes of audio reproduction. By the

time the sound reaches you, such as through an FM broadcast, dynamic range may be 50 decibels. An expander brings loud noises up and soft noises down.



The new RG-2 expander from Pioneer features a selection of preset amounts of expansion.



Carver's Sonic Holograph processes stereo so you hear sound from beyond speakers.



### Sound-in-the-round

Imagers and holographic generators will add an astounding third dimension to your stereo music. (Shown: Omnisonic Imager.)

### Digital delay

Right in your living room, you can have the same "live" sound as in a club, theater, even auditorium. (Shown: Koss K/4DS.)



### Big sound—tiny phones

Headphones have shrunk down to a truly amazing size, but still pack a sonic wallop. (Shown: Audio-Technica .5.)

### Power-supply improvements

Big watts used to mean big, bulky power supplies. New receivers and amplifiers use advanced methods. (Shown: Yamaha A-760.)



### Decoders and noise limiters

Static and hiss have always come between man and his music. Now these annoyances have been lessened. (Shown: Dbx Decoder.)

### Depth and range regained

An expander restores the big difference between the softest sound in a passage and the loudest. (Shown: Dbx 3BX Expander.)





**C**adillac has traditionally been General Motors' innovator—distinctive in its styling and engineering. From the 1912 self-starter through the ohv V16 in 1930 to tail fins for 1948, Cadillac has historically prided itself on being first with the most.

Now, however, it's a race to be first with the least: smaller size, less weight, lower fuel consumption. And for a maker of traditionally big, heavy, roomy automobiles, Cadillac has had to develop something of a split personality. Its cars must maintain that distinctive, roomy, innovative character, while shrinking to fit the times.

How does one do all that? Offer a diesel, for one thing—the diesel V8, developed by Oldsmobile, and included in Cadillacs since 1979. For another, offer a variable-displacement V8 engine—an in-



Wide stance and supple suspension provide the usual Cadillac ride and road feel.



novation tried and rejected by Ford but carried through by Eaton. It will make its Cadillac debut in 1981. The question is: How well does the Cadillac V8-6-4 system work?

We interviewed Cadillac Sedan deVille owners, 77.4 percent of whom chose the standard-equipment, variable-displacement engine. These owners, while quite pleased with their cars as a whole, weren't totally satisfied with the 1981 engine innovation.

A New York field representative summed it up for the majority: "The V8-6-4 engine runs fine in the V8 and V4 modes, but the car shakes and vibrates when running as a V6. It's so bad I doubt

that I'll drive this car for long. Also, the fuel mileage is no better than that of the '78 Cadillac I traded."

True, the V6 came in about three miles per gallon ahead of the V8-6-4 for both city and highway driving. But our V8-6-4 respondents also reported figures slightly below the EPA estimates.

Instead of getting the EPA's projected 15/23 mpg, owners of the V8-6-4 Sedan deVille averaged 14.2/19.2 city/highway.



Most popular engine in survey was the V8-6-4, but the diesel proved most efficient.

This didn't cause a great hue and cry. Only 9.5 percent of those surveyed listed lower-than-expected gas mileage as a specific complaint and 9.1 percent mentioned that "better mpg" would be a welcome change.

A Kentucky foundry salesman commented, "I question the fuel-mileage advantage of the V8-6-4. The regular V8

BY MICHAEL LAMM WEST COAST EDITOR

## Its loyal owners praise high quality, but V8-6-4 needs to be improved



Owners praised interior workmanship and quality.

The V8-6-4 needs work, owners say.

High ride quality is still a Caddy trademark.

Common complaint: New engines require better transmissions.

PM photos: John W. Lamm





This year, many exotic electronic gadgets complement rich interior appointments.

of years past seemed to give similar mileage with smoother performance."

But let's leave the V8-6-4 for the moment and see what owners of the optional V6 and diesel V8 say.

An Ohio bearing-plant manager said of the V6, "This engine plus the overdrive automatic transmission—combined with style and roominess—sold me on the deVille. The V6 gives an excellent combination of performance and mileage."

A New York businessman, though, disagreed. "Cadillac should eliminate the V6 engine option entirely. The salesman said performance would be adequate, but the car lacks power."

An Ohio retiree went even further. "To put this underpowered V6 in this size car is a disaster," he opined.

How about the Olds-built diesel V8? What do owners think of that engine?

"Here's a car that's large enough to be comfortable on long trips," stated a Texas cost accountant, "which is what I use it for, mostly. I'm getting around 30 mpg and I am very pleased. So far, the car has been absolutely troublefree."

A Texas dentist: "This is my second Cadillac diesel and I like the good fuel economy this engine gives me. However, the diesel lacks some acceleration."

Americans tend to take more critical looks at quality and workmanship these days, so we were curious to get Cadillac owners' reactions. The vast majority—nearly 75 percent—rated workmanship good to excellent.

"It's undoubtedly a good car," observed a Michigan retailer, "but for the price, it ought to be better than good."

A Michigan engineer: "I'm a GM engineer and I know we put a great effort into building in quality. I consider that aspect of my Sedan deVille excellent. I have

*(Please turn to page 234)*



The Cadillac styling still sells. A full 36 percent of owners purchased it for its looks.

## Cadillac's 1981 Innovations

Cadillac offers three engines this year: a Buick-built 4.1-liter V6, an Olds-supplied 5.7-liter diesel V8 and Cadillac's own variable-displacement, 6.0-liter V8-6-4. The diesel is standard in the Seville; the V8-6-4 is standard in all others and optional in the Seville.

The V8-6-4 works basically like any standard V8, but when throttle position and road/load conditions warrant, computer-controlled solenoids deactivate certain rocker arms so the engine runs on only six or four cylinders. The deactivated cylinders are the end two on the left bank and the center twins on the right bank. It's a system Cadillac developed together with the Eaton Co.

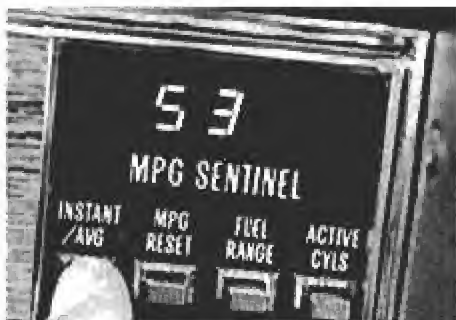
A dashboard display, called MPG Sentinel, keeps the driver informed of the number of firing cylinders. The onboard computer, sharing fuel-injection and cruise-control functions, can also conjure up projected fuel mileage and range.

Cadillacs come in eight body styles: Coupe deVille, Sedan deVille, Fleetwood Brougham sedan and coupe, Eldorado coupe, Seville sedan, plus seven- and eight-passenger Fleetwood limousines.

All '81 Cadillacs offer standard AM/FM stereo with digital display, automatic airconditioning, a water-in-fuel detector for diesels, plus the usual standard power accessories such as six-way power seats and an overdrive automatic transmission.

Major options include two-driver memory seats, automatic shoulder harness and firmer touring suspensions for Eldorados and Sevilles.

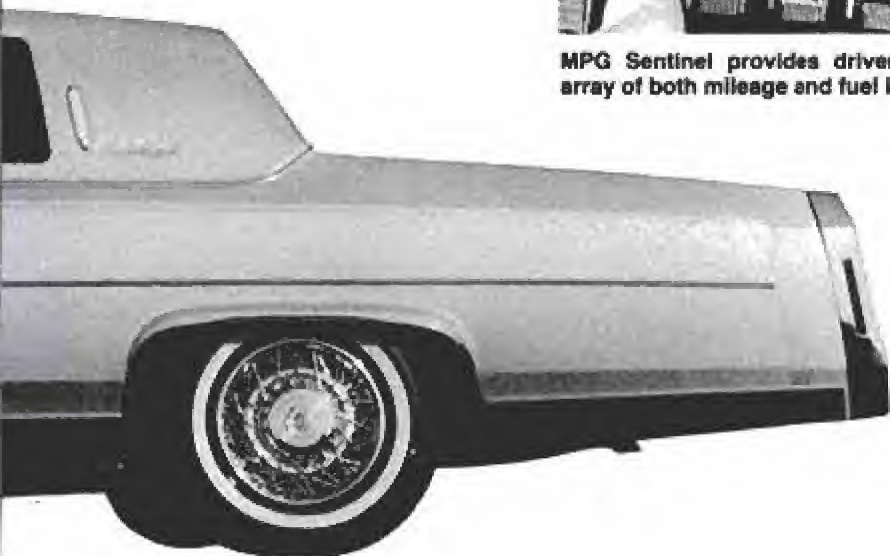
## A NATIONWIDE SURVEY BASED ON 816,741 OWNER-DRIVEN MILES



MPG Sentinel provides driver with vast array of both mileage and fuel information.

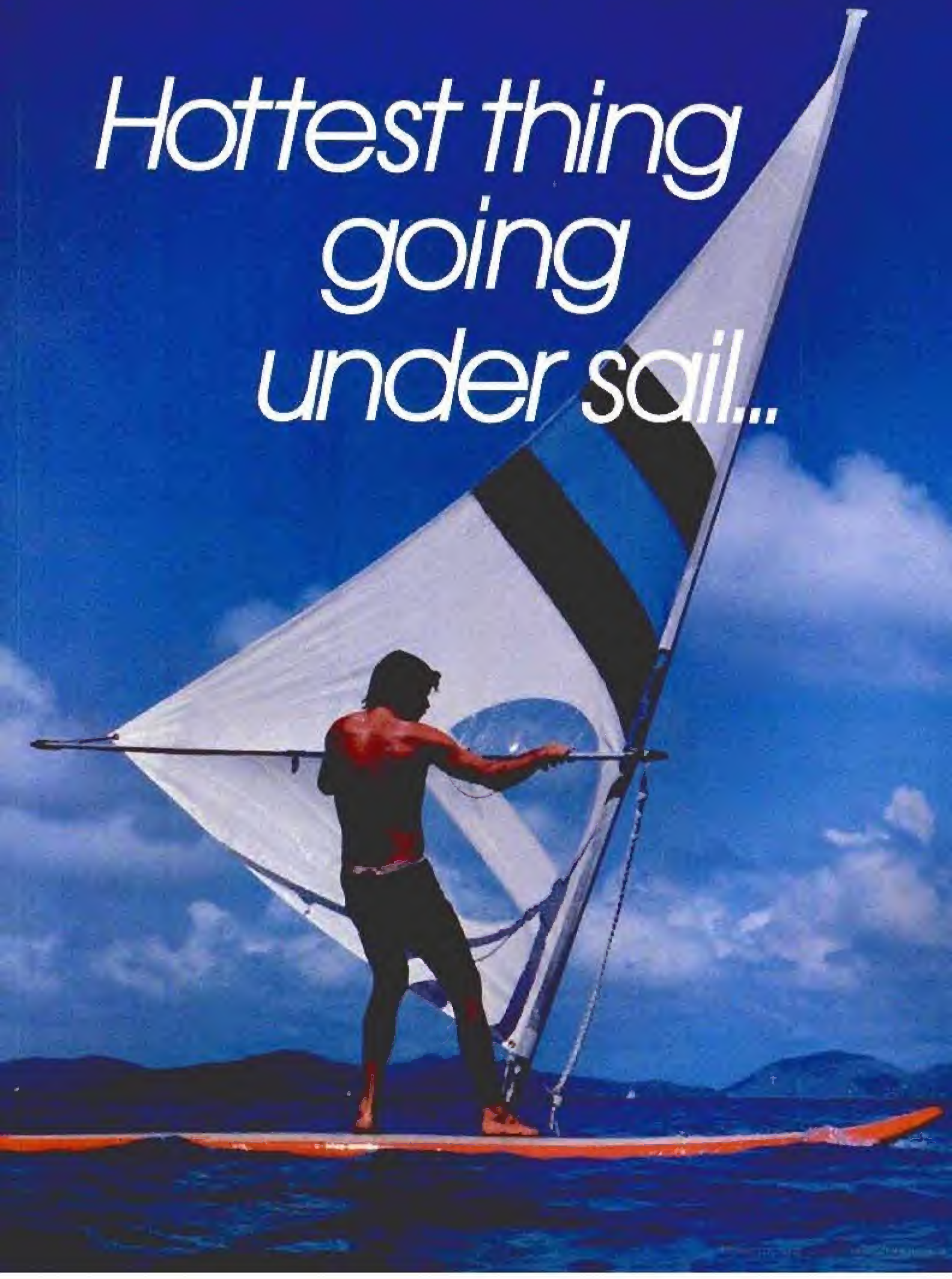


Rear-seat comfort and ride quality received high marks, as did the quality of materials.





*Hottest thing  
going  
under sail...*





Wind-powered surfboards are heading for new popularity and, in a couple of years, will be the newest sport for the 1984 Olympics.

by Bill McKeown  
BOATING EDITOR



Gliding smoothly or pulling up on plane (left), a sailboarder goes afloat for \$1000 or less. These Surf-Sailer SS models are from Canada.

Sailboarding skills include swimming, but the sport is so safe that wearing life preservers is not a requirement.



Riding the breakers in a strong breeze, a smaller sail is used; high-performance boards for racing and hot-dogging are also good for surf. Mast steps, dagger boards, toe holds are options.



Two ride on one Wind-surfer in doubles racing event for girls. Windsurfing also supplies a Star model for stability, and a Rocket for speed.



PM photo: Al Nomura

**S**ailing standing up is off and planing as the fastest growing of all water sports. Here's a boat that doesn't need a boatyard, launching ramp, trailer or motor. Just cartop or carry it to almost any body of water more than a foot deep, and after a little instruction and practice you're ready to go with the wind. Simple, sporty and speedy, the sailboard is now considered the quickest of all single-hulled craft, with record speeds approaching 30 mph. Only a large, multihull racing machine might be able to outrun it.

Board sailing isn't brand new. Fifteen years ago we showed an example of the sport (page 106, July '66). Several years later, Californian Hoyle Schweitzer produced his Windsurfer. Initially, it didn't sail away with big sales in the States, but sailors across the Atlantic saw this surfboard with a sail as an ideal, inexpensive way to go afloat. Today, an estimated 300,000 sailboards are in use in Europe, and now the popularity of the sport appears to be returning to North America.

And a bigger push is on the way. Recently, the International Olympic Committee accepted board sailing as a new sport to be included in the next Olympics, when the games are held at Long Beach, Calif., in 1984. Late last year, the International Yacht Racing Union selected the Windglider board as the Olympic competition boat.

#### A lot to choose from

It's estimated that at least 80 companies now produce sailboards in the United States and abroad. Though there are differences in design, the measurements average about 12 feet in length, 2 feet or more in beam and 45 pounds in weight, with a 14-foot mast that mounts approximately 55 sq. ft. of sail. Under the back of the board there are one or two skegs to help hold the craft on course. A centerboard adds vertical stability, but below the stern there is no rudder. Instead, the sailboard is steered by the balance and footwork of the sailor.

The rudderless rig adds simplicity



and challenge. And rather than a conventional boom along the bottom of the sail, the loose-footed sail is held in place by a wishbone boom—a shallow oval shape that straddles the sail at arm level to provide control from either side. To change tacks and come about, a board sailor changes sides in front of the mast.

While the rigs seem to tip over easily, they have proved to be remarkably safe. Once the sail is down in the water, it acts as a sea anchor to keep the board from drifting away from the swimmer. There is so much flotation in the hull that this is the only "boat" that is not required by the U.S. Coast Guard to carry life preservers for each crew member.

Learning board sailing is much faster after initial instruction ashore, particularly with a pivoting simulator that can give the sensations of the sport. Windsurfer and Sailrider dealers conduct classes to get a beginner started properly. Several builders supply boards especially designed for learners and heavier sailors, and for racers and hot-doggers who like to tackle waves and heavy air.

In addition to its basic model, Windsurfing International has Star, Rocket, Sport and Sprint boards, plus sails for varying conditions. The Porsche design group has created single- and twin-sail tandem sailboards. A Dufour Wing has rounded Cape Horn under sail and cruised 137 miles in 24 hours. Or, for an extra-stable ride, try a Kona-Kat, a catamaran board sailer with twin parallel hulls.

### Boards are lightest yet

Though the first boards were built of fiberglass and quite heavy, models are now available in polyethylene, ABS and ASA plastic, ethafoam and fiberglass-covered foam for lighter weight and increased durability. Board shapes still resemble surfboards, but innovations in deck and bottom form are available. Each brand has a different shape for the transparent panel in the sail. Advanced models offer alternate mast step positions on the deck, toe straps and various fixed or hinged centerboards.

Accessories include wide selections of colorfully striped sails, wet suits that extend the sailing season, sportswear, board-sailing nonslip shoes, gloves, equipment bags and even speedometers. Advanced sailors may try a trapeze harness with mini-backpack.

And for dedicated sailboarders, membership in the U.S. Board Sailing Assn. (USBSA), Box 206, Oyster Bay, N.Y. 11771, is \$7.50. **PM**

# ...and how



Speeds up to 15 mph are possible on PM's exciting sailboard. A wet suit lets you sail in weather too chilly for a bathing suit and provides comfort if you go over.

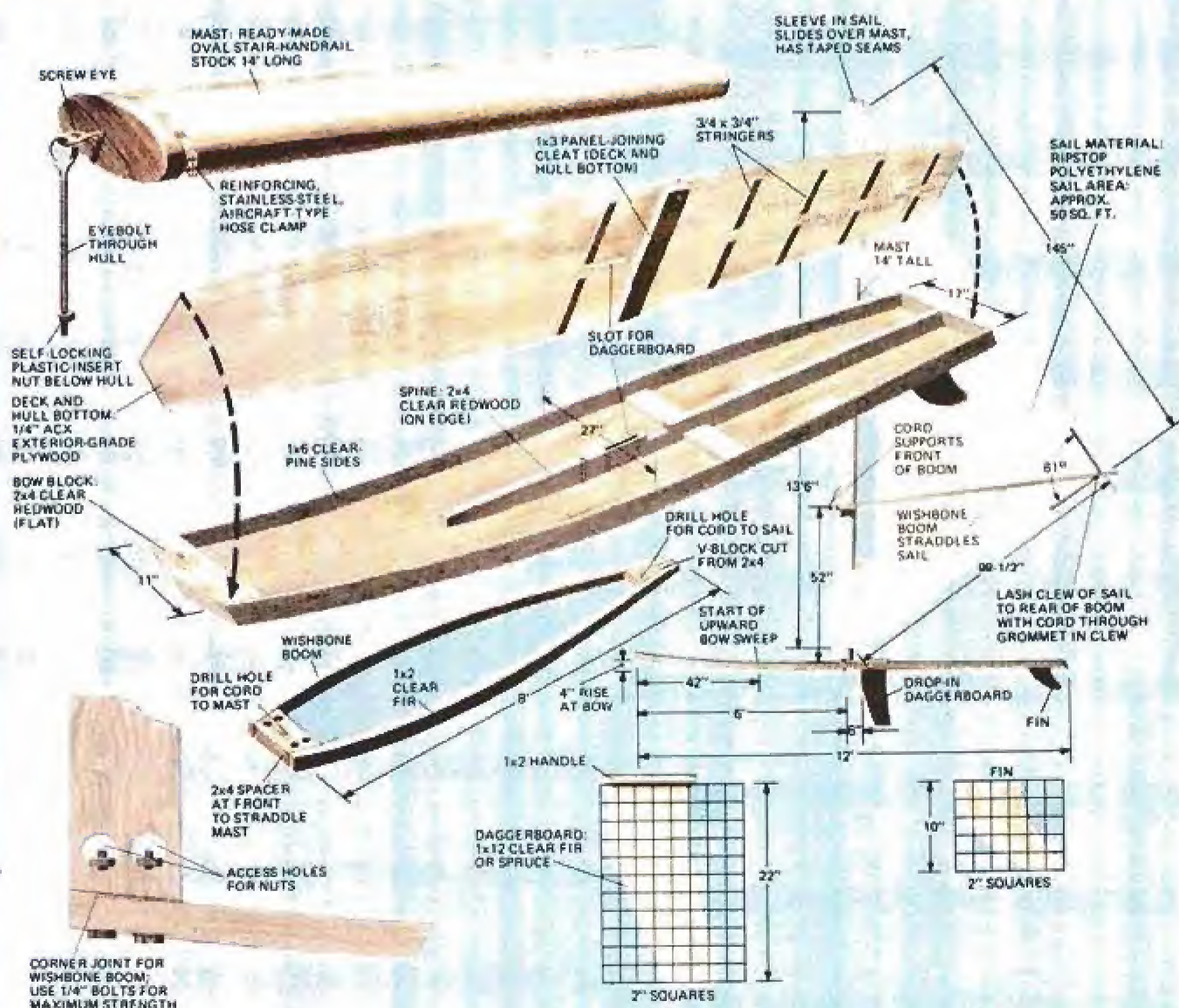


Rigging the craft takes only a few minutes. Basic parts (from left, above) are wishbone boom, drop-in daggerboard keel, mast and slim, surfboard-like hull. The oval-shaped, double-spar boom straddles sail to permit control from either side.





# to build one



**W**ith PM's homebuilt sailboard, you can skim the waves at breathtaking speeds of up to 15 mph—and on water under sail that's really traveling. The sailing surfboard is designed along the lines of sleek commercial models costing \$1,000 or more (see preceding story), but it can be built for about \$140, including sail, rigging and finishing materials.

The slim plywood hull is 12 feet long, yet weighs only 55 pounds—light enough for convenient cartopping to and from water and easy handling by one person. Its 14-foot mast carries just under 50 square feet of sail—enough to provide brisk sailing even in light breezes.

In addition to the construction details shown above, complete plans for build-

ing the PM sailboard are available separately for your convenience. These include large-size drawings, patterns for irregular-shaped pieces and helpful assembly tips. For information on how to order plans, see the note below.

The thin, flat-bottomed sailboard has a small, fixed fin at the stern and a removable daggerboard that fits in a slot just behind the mast to serve as a keel. The drop-in daggerboard makes it easy

to operate in shallow water without snagging the bottom. You lower it as you move out into deep water, then retract it as you return to shore.

The hollow, self-buoyant hull is a sandwich of 1/4-inch ACX exterior-grade plywood, spaced apart by 1-inch stock at the sides, and a center 2x4 spine extending 9 feet forward from the stern. Because of the 12-foot length, it's necessary to make the deck and bottom panels from two strips of plywood spliced together near the midpoint of the hull. Note that the splices are slightly offset so they don't fall directly above each other.

To establish the hull shape, lay out a centerline on plywood, then mark off the three key width dimensions at right

(Please turn to page 233)

## HOW TO ORDER PLANS

Complete plans for building PM's sailboard are \$7 postpaid. Send your check or money order to PM Sailboard, Stevenson Projects, Dept. W-61, Drawer K, Del Mar, Calif. 92014. Please make payable to Stevenson Projects. Allow three to four weeks for delivery by third-class mail. If you prefer faster first-class mail, add 75 cents.



# Build PM's desk for your

**W**hen we showed readers how to recreate this electronically equipped home office (*A Master Craftsman Builds His Own Home Office*, page 135, Apr. '81), we promised to present plans in a later issue for building the desk—control center of this up-to-date office—and the bookcase-cabinets. Both pieces are carefully designed to meet the occupant's needs, yet be compatible with

Here are plans for building the desk and the matching bookcase-storage cabinets from PM's electronic office.

the 18th-century decor of the office.

Although we used a steel filing cabinet in our desk, we show alternate plans for building desk files. Begin work by ripping the sides,

front, partition (F), desk return sides (D) and lower cabinet member (J); see materials list, page 116. If you want to use a commercial filing cabinet, omit parts J, R-U and EE. Join desk parts with glue and No. 10  $\times$  1½-in. flathead wood screws.

Cut enough base molding to enclose the perimeter of the desk; edge the plywood molding with solid oak glued in place and clamped. Put the



The spacious desktop (left) holds needed electronic equipment conveniently at hand. The left side of the desk (above) contains a two-drawer steel filing cabinet. If you prefer, you can build your own files according to the plans on the following pages.



Desk-return detail above shows storage area. Desk frame is being assembled at right. Prebore holes and test fit parts.





# home office electronics



The PM desk (above) houses electronic office equipment such as a word-processing computer keyboard and monitor, a hold-a-phone unit that controls two telephone lines and a telephone-answering service. The computer's line printer can be located out of the way, as it is here on a nearby lateral file.

Twin floor-to-ceiling bookcases with closed storage space (left) are made of red oak plywood. The bookcases are traditionally styled to be companion pieces with electronic work center desk. Exposed plywood edges are covered with thin strips of solid oak.



molding aside for application later.

Cut the desk and return tops to size. Glue and clamp oak edging to all sides except that of the return which attaches to the desktop.

Next, cut the desk-return parts (L, M, V). Put the shelves aside and attach L and M with glue and No. 10  $\times$  1½-in. flathead screws. Then attach ¾  $\times$  ¾-in. cleats (see section 5 of drawing below). Attach the bottom (V) to these cleats with glue and brads.

Cut and apply edging to the plywood edges of the return and the filing cabinet with glue and 4d finishing nails. Bore slightly undersized pilot holes first. Cut corner blocks and secure them with No. 10  $\times$  2-in. flathead wood screws.

At this point, cut the back and back rail, and notch the partition (F) for the rail. Also cut and notch drawer supports (I) and attach them to the front, back and back rail with

glue and 6d finishing nails. Fill all visible holes with wood filler.

Cut filing drawer parts (R-U) or else use a commercial filing cabinet. Make ¼  $\times$  ¼-in.-deep grooves in the sides, front and back for the bottom. Assemble the drawer with glue and 6d nails, allowing the bottom to float in the grooves. Space nails evenly on the front. Clamp and check drawers for square; let them dry overnight. Attach slides (EE) according to maker's directions; attach cabinet pulls. Secure base molding to the desk with No. 10  $\times$  1½-in. flathead screws, mitering all corners.

For the middle drawer, cut parts N-Q and make oversize grooves in sides and back for the bottom; glue and nail. Check for squareness, clamp and attach drawer slides.

Bore holes in the desk return for shelf supports. Cut finger recesses and install the shelves. Cut and edge door on return. Add door hardware.

Attach tops with screws from the bottom of the corner blocks and rails into the underside of the tops. Using 1-in. brads and glue, apply oak strips (Z) to simulate rails and stiles. Fill nail holes.

The bookcase-cabinet combinations are made of the same oak plywood and trim. You may alter the dimensions to suit your space.

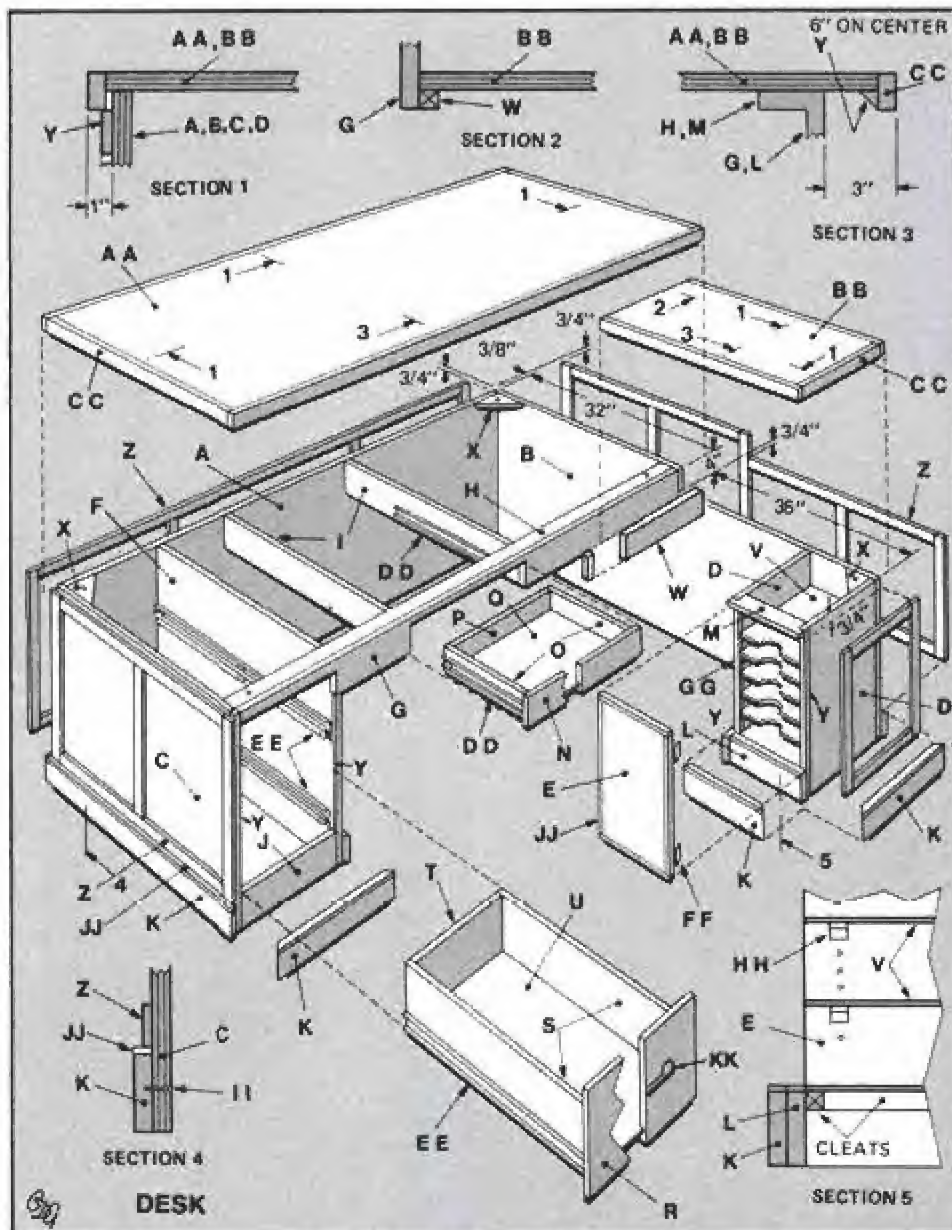
Begin by building the cabinet. First, cut all ¾-in. plywood to size (sides, bottom, top, upper and lower fastening rails, supports and kick-plate). To prevent chipping, use masking tape on the down side of the panel. Cut ¼  $\times$  ¼-in. rabbets in the sides and fastening rails.

Assemble sides, bottom, fastening rails, supports and corner blocks using glue and 8d finishing nails. Glue on the back and nail with No. 4 box nails; check the cabinet for squareness. Once it is squared, tack a temporary brace on it overnight.

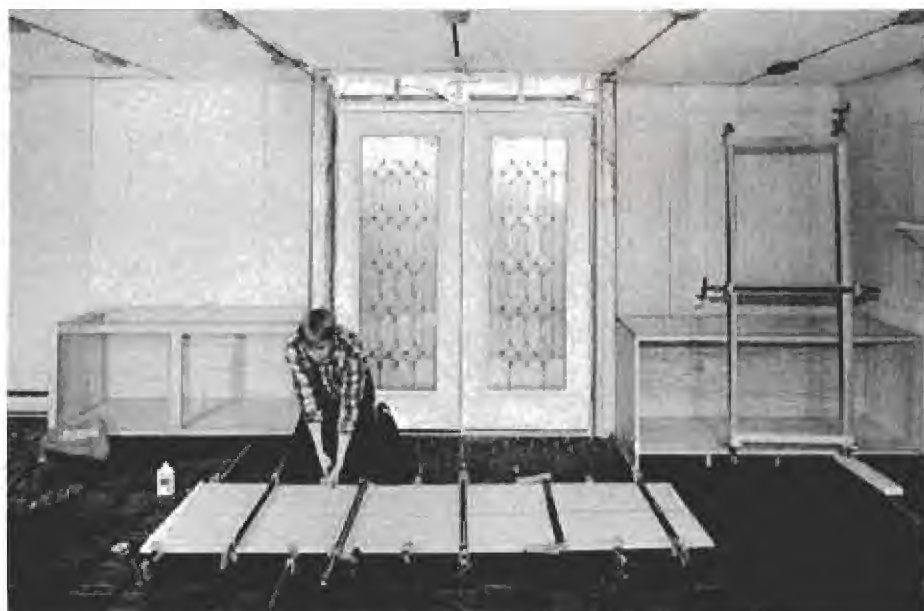
#### MATERIALS LIST—DESK

| Key | Amt.     | Size and description (use)                                |
|-----|----------|---|
| A   | 1        | ¾ $\times$ 29¼ $\times$ 76" oak-veneer plywood (front)    |
| B   | 1        | ¾ $\times$ 29¼ $\times$ 67" O.V.P. (side)                 |
| C   | 1        | ¾ $\times$ 29¼ $\times$ 31¼" O.V.P. (side)                |
| D   | 2        | ¾ $\times$ 12¼ $\times$ 25¼" O.V.P. (returns)             |
| E   | 1        | ¾ $\times$ 11 $\times$ 20½" O.V.P. (drawer front)         |
| F   | 1        | ¾ $\times$ 29¼ $\times$ 29¾" O.V.P. (partition)           |
| G   | 1        | ¾ $\times$ 4¼ $\times$ 76¾" O.V.P. (back)                 |
| H   | 1        | ¾ $\times$ 2 $\times$ 76" O.V.P. (back rail)              |
| I   | 2        | ¾ $\times$ 4¼ $\times$ 30½" O.V.P. (drawer supports)      |
| J   | 1        | ¾ $\times$ 4¼ $\times$ 14½" O.V.P.                        |
| K   | as reqd. | ¾ $\times$ 3½" $\times$ (as needed) O.V.P. (base molding) |
| L   | 1        | ¾ $\times$ 3½ $\times$ 11½" O.V.P.                        |
| M   | 1        | ¾ $\times$ 2 $\times$ 11½" O.V.P.                         |
| N   | 1        | ¾ $\times$ 4 $\times$ 20" solid oak (drawer front)        |
| O   | 2        | ¾ $\times$ 3½ $\times$ 15" solid oak (drawer sides)       |
| P   | 1        | ¾ $\times$ 3½ $\times$ 17½" O.V.P. (drawer back)          |
| Q   | 1        | ¼ $\times$ 15½ $\times$ 18" plywood (drawer bottom)       |
| R   | 2        | ¾ $\times$ 12½ $\times$ 18" solid oak (drawer fronts)     |
| S   | 4        | ¾ $\times$ 7 $\times$ 30" O.V.P. (drawer sides)           |
| T   | 2        | ¾ $\times$ 7 $\times$ 12" O.V.P. (drawer backs)           |
| U   | 2        | ¼ $\times$ 12½ $\times$ 30½" plywood (drawer bottoms)     |
| V   | 6        | ¼ $\times$ 10 $\times$ 13" hardboard (shelves and bottom) |
| W   | 1        | ¾ $\times$ 4 $\times$ 17" O.V.P. (cleat)                  |
| X   | 3        | ¾" O.V.P. (corner blocking)                               |
| Y   | 5        | ¾ $\times$ ¾" $\times$ (as needed) solid oak (edging)     |
| Z   | as reqd. | ¾ $\times$ 1¾" $\times$ (as needed) solid oak (trim)      |
| AA  | 1        | ¾ $\times$ 34½ $\times$ 76½" O.V.P. (top)                 |
| BB  | 1        | ¾ $\times$ 17½ $\times$ 35¼" O.V.P. (top)                 |
| CC  | as reqd. | ¾ $\times$ 1½" $\times$ (as needed) solid oak (edging)    |
| DD  | 1 pr.    | KV No. 1205 self-closing drawer slide (see note 2 below)  |
| EE  | 2 pr.    | KV No. 1395 full-extension drawer slide                   |
| FF  | 2        | ¾ $\times$ 2" butt hinges                                 |
| GG  | 1        | KV No. 816 magnetic catch                                 |
| HH  | as reqd. | KV No. 346 brass shelf supports                           |
| II  | as reqd. | 1½" No. 10 fh screws                                      |
| JJ  | as reqd. | ¼ $\times$ ¾" $\times$ (as needed) solid oak (edging)     |
| KK  | 2        | file cabinet pulls to suit decor                          |

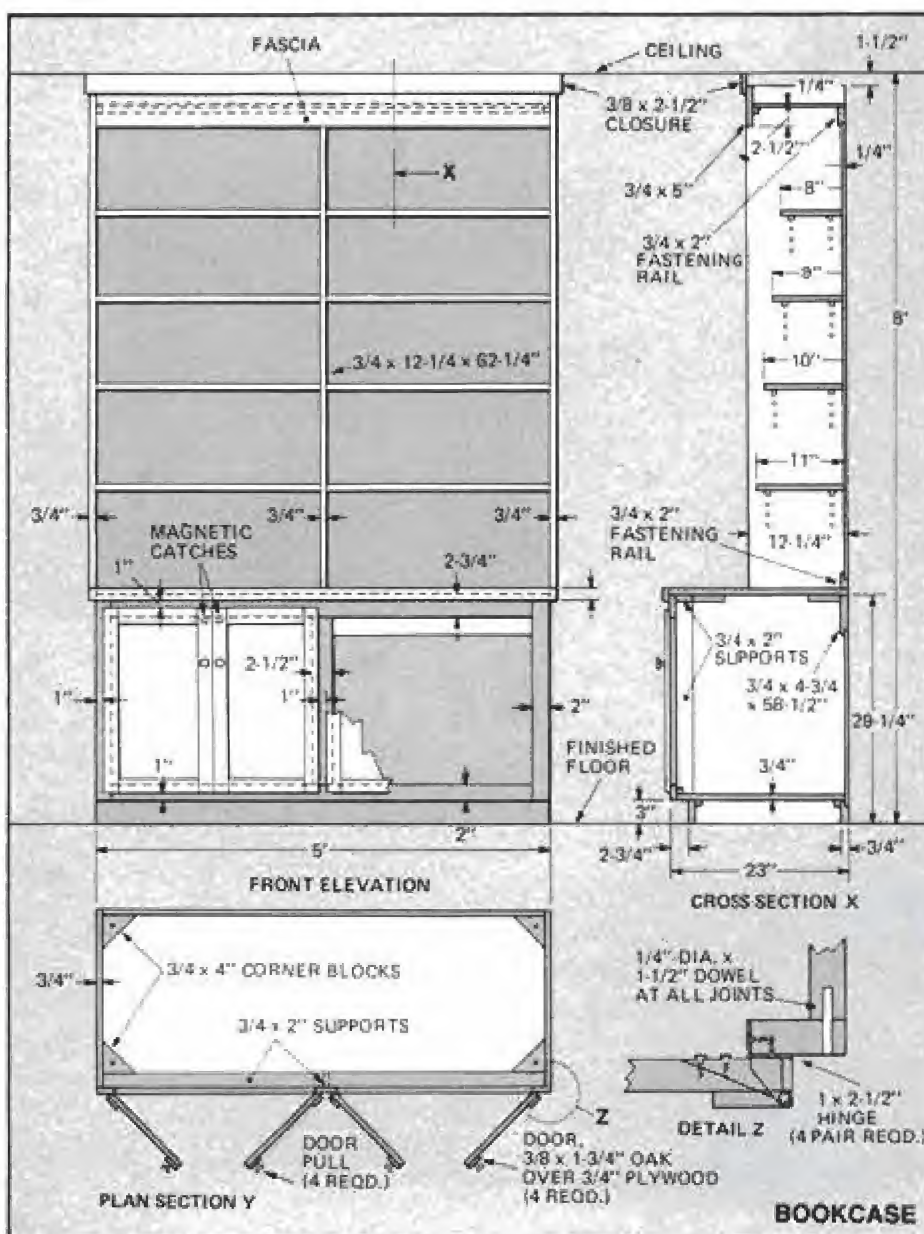
Misc.: No. 10  $\times$  2" fh wood screws, 1" brads, glue, No. 10  $\times$  1½" fh screw, ¾  $\times$  ¾" scrapwood cleats (length to suit), ¾" oak veneer trim, 6d nails  
Five-ply oak-veneer plywood: Columbia Plywood Corp., Box 1780, Klamath Falls, Ore. 97601; Hardware specified: Knappe & Vogt Mfr. Co., 2700 Oak Industrial Drive N.E., Grand Rapids, Mich. 49505; Two-drawer steel desk file: The Hon Co., 414 East Third St., Muscatine, Iowa 52551. O.V.P. denotes oak-veneer plywood.







To edge the side panels on the bookcase, glue and clamp  $\frac{3}{4}$ -in.-wide strips of oak to the plywood sheet. After the glue has dried, rip the sheet down the center.



Attach the solid wood frame for the front with two dowels per length of member. Edge the front of the top with solid oak strips. Attach the top to the cabinet with screws driven through the corner blocks.

Glue  $\frac{1}{4} \times 1\frac{1}{2}$ -in.-wide oak-veneer tape on the ends of the cabinet to cover the raw edge of the plywood top and to suggest a  $1\frac{1}{2}$ -in.-thick, solid oak top.

Cut doors, allowing for  $\frac{1}{4}$ -in. edging. To edge the plywood sides, place a  $\frac{1}{4} \times \frac{1}{4}$ -in.-wide board between two pieces of plywood, glue and clamp. When dry, rip down the center of the oak strip leaving  $\frac{1}{8}$ -in. oak on each piece. Plane the edge smooth and sand the faces. Edge the opposite sides the same way. Edge the door tops with  $\frac{3}{4}$ -in. veneer tape. Sand front and back smooth.

Glue oak strips to door fronts for a panel effect. Hinge the doors to the cabinet with Stanley No. 332 cabinet pivot hinges. Install Baldwin brass pulls No. 4655 and Stanley cabinet roller catches No. 38. Brass pulls can be ordered by mail from Baldwin Manufacturing Corp., 841 Wyomissing Blvd., Reading, Pa. 19603. Stanley items are at most hardware stores, or write: Stanley Hardware, New Britain, Conn. 06050.

Start building the bookcase by ripping enough  $\frac{3}{4} \times \frac{3}{4}$ -in. solid oak (about 45 feet) to edge the front of the plywood uprights and shelves. Shelves are  $\frac{1}{4}$ -in. shorter than the space between uprights.

Cut uprights to length. Then mark for  $\frac{1}{4}$ -in. shelf peg holes and bore through the center board. Use this to bore matching blind holes  $\frac{1}{4}$ -in. into the bookcase sides.

Cut rabbets for the back. Use 8d finishing nails and glue to assemble the top to the fascia board. Carefully drive nails to avoid splitting. Fasten sides to the top. Position the center upright and 2-in. fastening rails. Cut the back panel, fasten it with 4d common nails and glue.

Slide the bookcase onto the cabinet and locate the wall studs. Pre-bore fastening rails and fasten case to studs with  $2\frac{1}{2}$ -in. No. 8 flathead wood screws and finishing washers.

Cut oak trim for top and install with 4d finishing nails. Insert shelf supports (No. H2700 from Craftsman Wood Service, 2727 South Mary St., Chicago, Ill. 60608 were used here).

To finish the desk and bookcase, sand with 80- and 120-grit paper, dust and wipe with a tack cloth. Apply stain and your choice of finish according to the maker's directions.

PM



1

# 4 great playthings to make for youngsters



2



One of the more rewarding aspects for the active home work-shopper is building things for children.

The reward is two-fold: First, you get to share the joy that is triggered by the giving of toys such as those pictured on this page. The second is the smug satisfaction of being a "hero" (that only the builders of kids' furniture ever get to know).

On these pages we have rounded up four fun projects to keep you and your children busy. We built three of them in the PM workshop—and tested the prototype digger at length—before we photographed the projects for publication.

(Please turn to next page)





- 1** PM's boy-powered digger works beautifully—just like the real ones—and will give the young user hours of fun.
- 2** Sleek model racer is easy to make: body is cut from a scrap piece of 2x4. Mag wheels are created using a hole saw; the clever roll bar is a U-bolt.
- 3** Here's a play center to wow preschoolers (and older youngsters). It has a play TV, bulletin board, chalkboard (top), and place to make up (above).
- 4** Doll cradle is reproduction of 18th-century cradle. Ours is handcrafted of mellow pine with varnish finish.







## Boy-powered digger

This is a controlled bucket for the young operator and feet to work in snow.

Making the sheaves. Start by making out and cut the six pulleys.



the sheave is turned so that two turns of cable.



ecesses are routed in the truck sides to simulate authentic-looking cab windows.



The aluminum parts for the bucket were bent using a small bending brake.

in.-thick hardwood with a band saw. One easy way to mount the stock in the lathe for turning is to bore a  $\frac{1}{4}$ -in. center hole in each blank and use a  $\frac{1}{4}$ -20 machine screw turned into your tapered screw center after removing the existing screw. Turn the outside diameter of the sheave blank true, then turn a groove  $\frac{1}{16}$ -in. wide by  $\frac{1}{8}$ -in. deep for the cable. Round-over both edges of the sheave. Smooth up the face, leaving the center slightly thicker than the edges for clearance. Sand and finish with varnish, then remove the stock from the lathe.

Enlarge the center hole on all sheaves to achieve a running fit on the  $\frac{1}{4}$ -in. axles. To do it, use a  $\frac{1}{32}$ -in. bit. Watching the bank of sheaves turning is part of the enjoyment that the young operator derives from using this toy.

Bore holes through the sheaves from groove to groove parallel with



Through-holes in sheaves are bored parallel to diameter, but offset from axle holes.



Because truck is for outdoors, assemble it with waterproof glue, finishing nails.



The bucket pivots on end of arm; the spacers on the rod keep the bucket centered.

the diameter, but offset slightly to miss the axle holes. These holes should be  $\frac{1}{16}$  in. in the small and one of the medium sheaves, and  $\frac{1}{32}$  in. in the large and three of the medium sheaves. Bore the holes across the grain for strength. Drill and countersink for sheet-metal screws at right angles to the cable holes for locking the cable in the sheave where needed.

## The boom and arm

Cut the boom pieces from the  $\frac{1}{2}$ -in. exterior plywood as shown. Tack the pieces together in groups of two. On your jointer (or with a hand plane) make an overall  $\frac{1}{4}$ -in. taper on the width of both stacks. Lay out the  $\frac{1}{4}$ -in. holes, spaced 16 in. on center. Scribe the rounded ends with a compass, then cut and sand the rounded ends of the stacks. Bore the  $\frac{1}{4}$ -in. axle holes, then disassemble the

(Please turn to page 236)



Boom and arm are assembled with axles and sheaves in place temporarily for fit.



Tire faces and treads are turned on lathe; note dead center supporting workpiece.



Sheave rotational positions and relationship must be carefully



# 3 more great projects

When we featured four outdoor projects from Scandinavia in our August 1980 issue, readers liked them and asked for more. Here are three for indoor use.

**S**leek-looking, functional Scandinavian furniture is receiving a lot of attention these days. This popularity stems from the furniture's clean lines and its economy of materials. Homemakers and decorators find the Scandinavian style (in some ways reminiscent of Shaker furniture) easy to incorporate into existing decorating schemes, or to fit into odd areas where more conventional furniture may seem too large or bulky. In general, construction techniques are not intricate. The versatility of the three-way collapsible table implies more complicated construction than required.



This bench is large enough to display a thick reference book like a dictionary or a book but it's also sufficiently compact to be used in a foyer.

Youngsters will love this bench in their rooms. Its hinged seat lifts for access to storage space for clothing, favored dolls and toys.

Things aren't always as they seem: This smart-looking coffee table also functions as a stand-up work surface. Secret is in way legs work.

1





## Boy-powered digger

**T**his is an ideal project for the craftsman who wants to build an exceptional toy for his youngster. The digger works beautifully and provides hours of fun and exercise for its proud young owner.

Utilizing a cable and sheave mechanism, the arm and boom are precisely operated with hand levers, while the attitude of the bucket for loading and dumping is controlled with a foot pedal. The young operator uses both hands and feet to operate the machine, which works fine in sand, sawdust, or snow.

### Making the sheaves

Start by making the boom mechanism and sheaves. Lay out and cut the six pulleys and sheaves from  $\frac{1}{4}$ -

in.-thick hardwood with a band saw. One easy way to mount the stock in the lathe for turning is to bore a  $\frac{1}{4}$ -in. center hole in each blank and use a  $\frac{1}{4}$ -20 machine screw turned into your tapered screw center after removing the existing screw. Turn the outside diameter of the sheave blank true, then turn a groove  $\frac{1}{16}$ -in. wide by  $\frac{1}{8}$ -in. deep for the cable. Round-over both edges of the sheave. Smooth up the face, leaving the center slightly thicker than the edges for clearance. Sand and finish with varnish, then remove the stock from the lathe.

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Bore holes through the sheaves from groove to groove parallel with

the diameter, but offset slightly to miss the axle holes. These holes should be  $\frac{1}{16}$  in. in the small and one of the medium sheaves, and  $\frac{1}{32}$  in. in the large and three of the medium sheaves. Bore the holes across the grain for strength. Drill and countersink for sheet-metal screws at right angles to the cable holes for locking the cable in the sheave where needed.

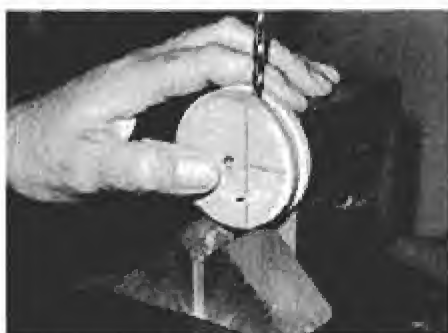
### The boom and arm

Cut the boom pieces from the  $\frac{1}{4}$ -in. exterior plywood as shown. Tack the pieces together in groups of two. On your jointer (or with a hand plane) make an overall  $\frac{1}{4}$ -in. taper on the width of both stacks. Lay out the  $\frac{1}{4}$ -in. holes, spaced 16 in. on center. Scribe the rounded ends with a compass, then cut and sand the rounded ends of the stacks. Bore the  $\frac{1}{4}$ -in. axle holes, then disassemble the

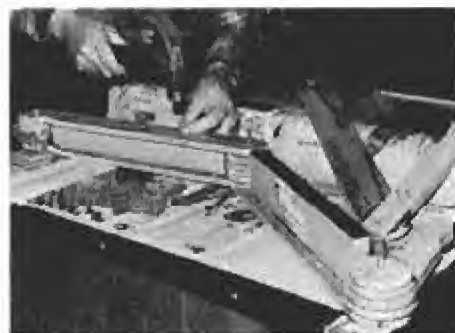
*(Please turn to page 236)*



The cable groove in the sheave is turned so it will accommodate two turns of cable.



Through-holes in sheaves are bored parallel to diameter, but offset from axle holes.



Boom and arm are assembled with axles and sheaves in place temporarily for fit.



Recesses are routed in the truck sides to simulate authentic-looking cab windows.



Because truck is for outdoors, assemble it with waterproof glue, finishing nails.



Tire faces and treads are turned on lathe; note dead center supporting workpiece.



The aluminum parts for the bucket were formed by using a small bending brake.



The bucket pivots on end of arm; the spacers on the rod keep the bucket centered.



Sheave rotational positions and attitude relationship must be carefully checked.



# 3 more great projects with

When we featured four outdoor projects from Scandinavia in our August 1980 issue, readers liked them and asked for more. Here are three for indoor use.

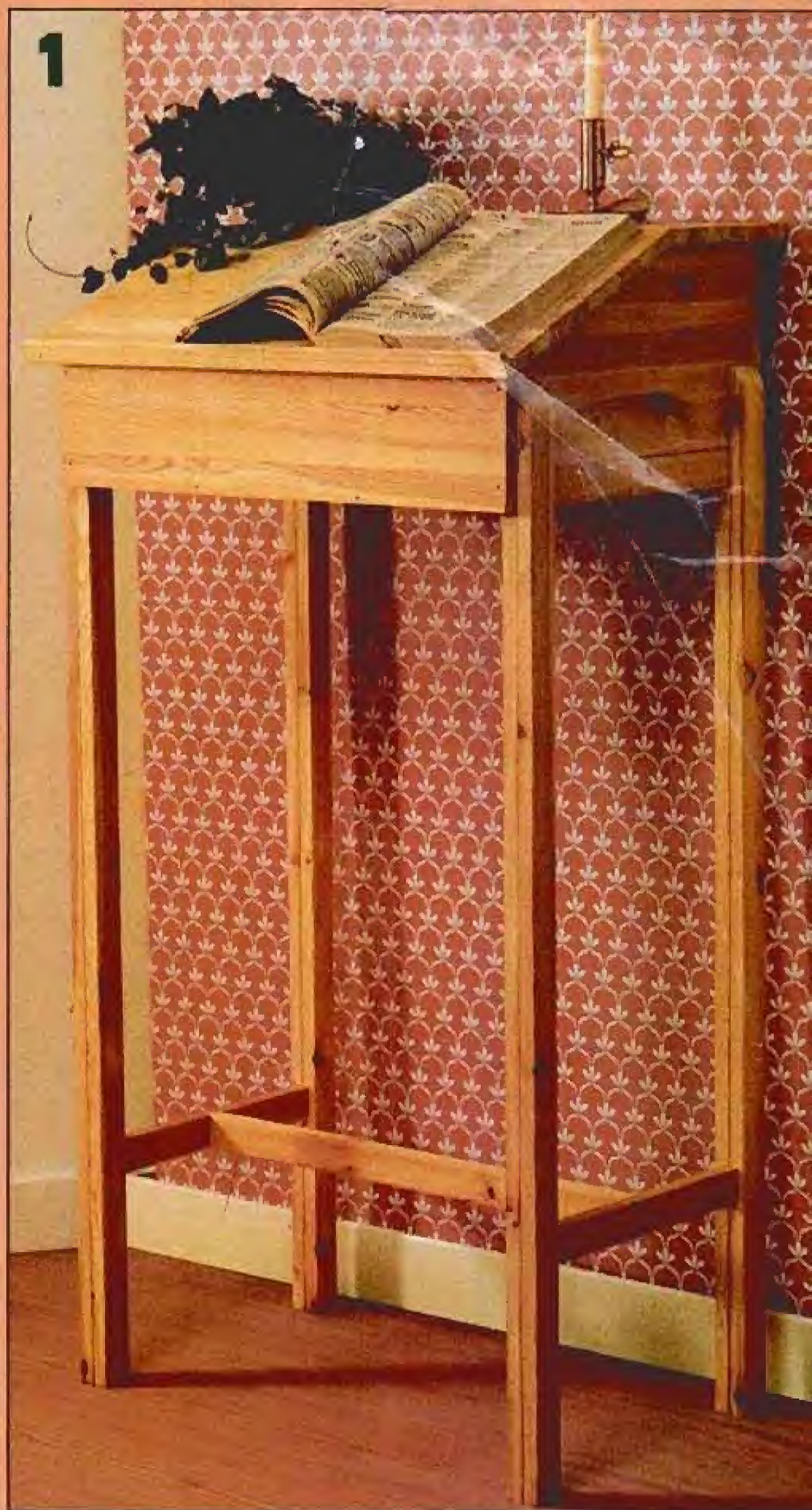
**S**leek-looking, functional Scandinavian furniture is receiving a lot of attention these days. This popularity stems from the furniture's clean lines and its economy of materials. Homemakers and decorators find the Scandinavian style (in some ways reminiscent of Shaker furniture) easy to incorporate into existing decorating schemes, or to fit into odd areas where more conventional furniture may seem too large or bulky. In general, construction techniques are not intricate. The versatility of the three-way collapsible table implies more complicated construction than required.



**1** Desk is large enough to display a thick reference book like a dictionary or phone book but it's also sufficiently sleek to be used in a foyer.

**2** Youngsters will love this bench in their rooms. Its hinged seat lifts for access to storage space for clothing or favored dolls and toys.

**3** Things aren't always as they seem: This smart-looking coffee table also is a dining table and stand-up work table. Secret is in way legs work.





# a Scandinavian flair

2



## High desk

**T**his distinctive high desk is built of solid pine using edge-joined boards. But if you plan to paint your desk, you can substitute lumber-core plywood and save yourself the doweling job.

Start by cutting the boards that are to be joined an inch longer than indicated in the materials list. This precaution will allow you to trim the pieces square after the glue has dried. Then lay out the boards and join them with dowels and glue as shown in the section-view drawing.

A few points to remember when using glue with soft wood: Apply glue sparingly, but coat both surfaces. Use scraps of wood between the clamp pads and workpiece to protect the latter from clamp marks. Immediately wipe off excess glue with a clean, damp cloth. Take extra care in this step if you plan to stain the wood; the slightest trace of glue on the surface will prevent the wood

3





# MATERIALS LIST—HIGH DESK

| Key | No.        | Size and description (use)                 |
|-----|------------|--|
| A   | 1          | 3/4" x 6" x 24" pine (front)               |
| B   | 1          | 3/4" x 10" x 24" pine (back)               |
| C   | 2          | 3/4" x 10" x 16" pine (sides)              |
| D   | 1          | 3/4" x 11 1/2" x 25 1/2" pine (lid)        |
| E   | 1          | 3/4" x 8 1/4" x 25 1/2" pine (top)         |
| F   | 4          | 3/4" x 1 1/2" x 44" pine (outer leg piece) |
| G   | 4          | 3/4" x 1 1/2" x 40" pine (inner leg piece) |
| H   | 2          | 3/4" x 1 1/2" x 14 1/2" pine (rail)        |
| I   | 1          | 3/4" x 1 1/2" x 23 1/2" pine (stretchers)  |
| J   | 1          | 1/2" x 16" x 22 1/2" plywood (bottom)      |
| K   | 1          | 1/4" x 1 1/4" x 25 1/2" pine (lip)         |
| L   | 2          | 3/4" x 2" butt hinge                       |
| M   | (as reqd.) | 6d finishing nails                         |
| N   | 2          | 2" No. 12 fh screws                        |
| O   | 8          | 1 1/4" No. 10 fh screws                    |

Misc.: Carpenter's glue, dowels.

Note: Parts A, B, C, D and E are all made from 1 x 4 pine edge-joined with dowels and glue.

beneath it from absorbing the stain. Allow joined work to dry overnight. Sand surfaces smooth with 120-grit sandpaper, then cut the boards to exact size.

Study the plans carefully, remembering that construction of any square shape is impossible without square parts. Check for square with a framing square. Also check the length of all parts and be sure to make bevel cuts on A and E before construction begins. Cut the diagonal line on sidepieces (C).

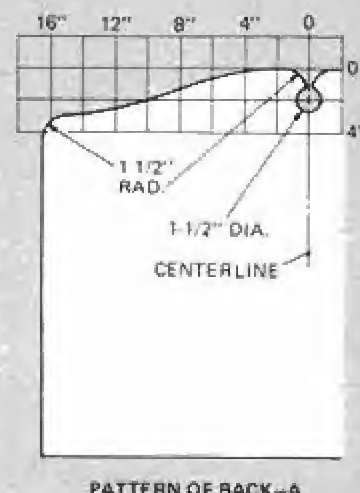
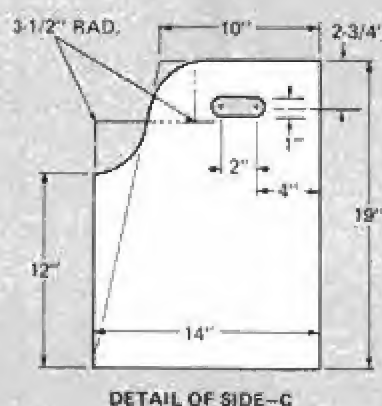
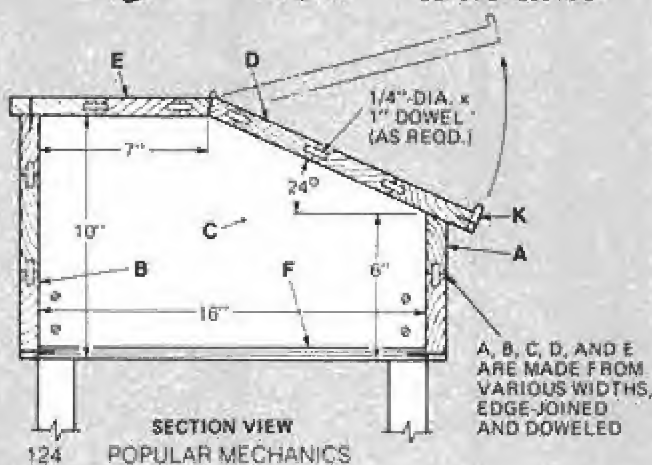
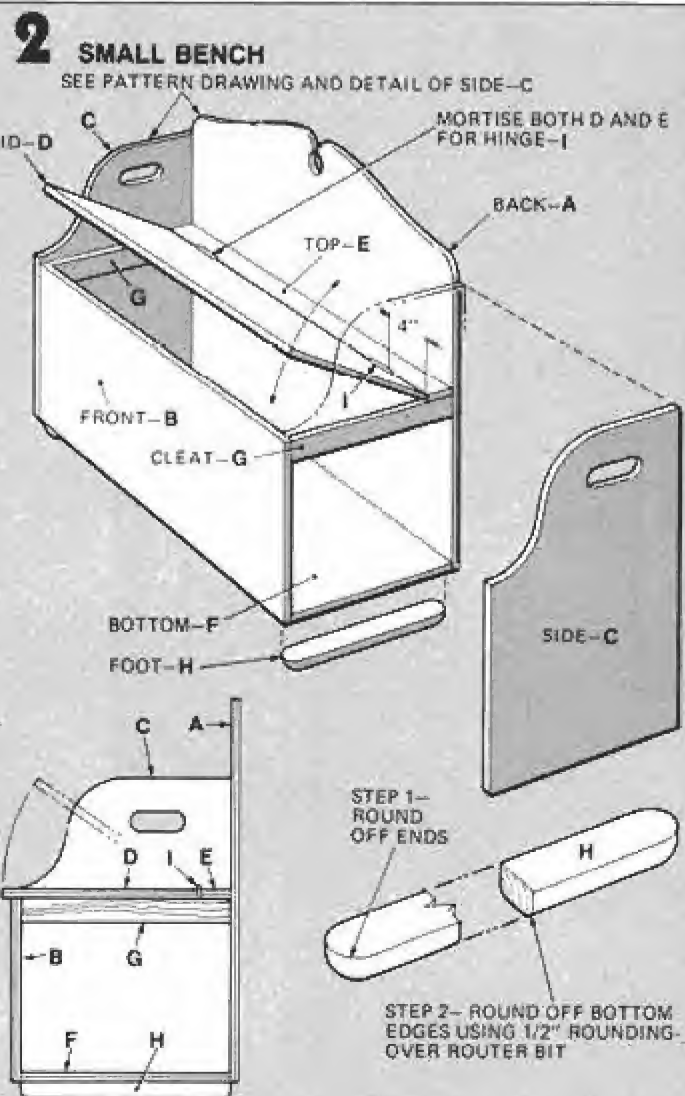
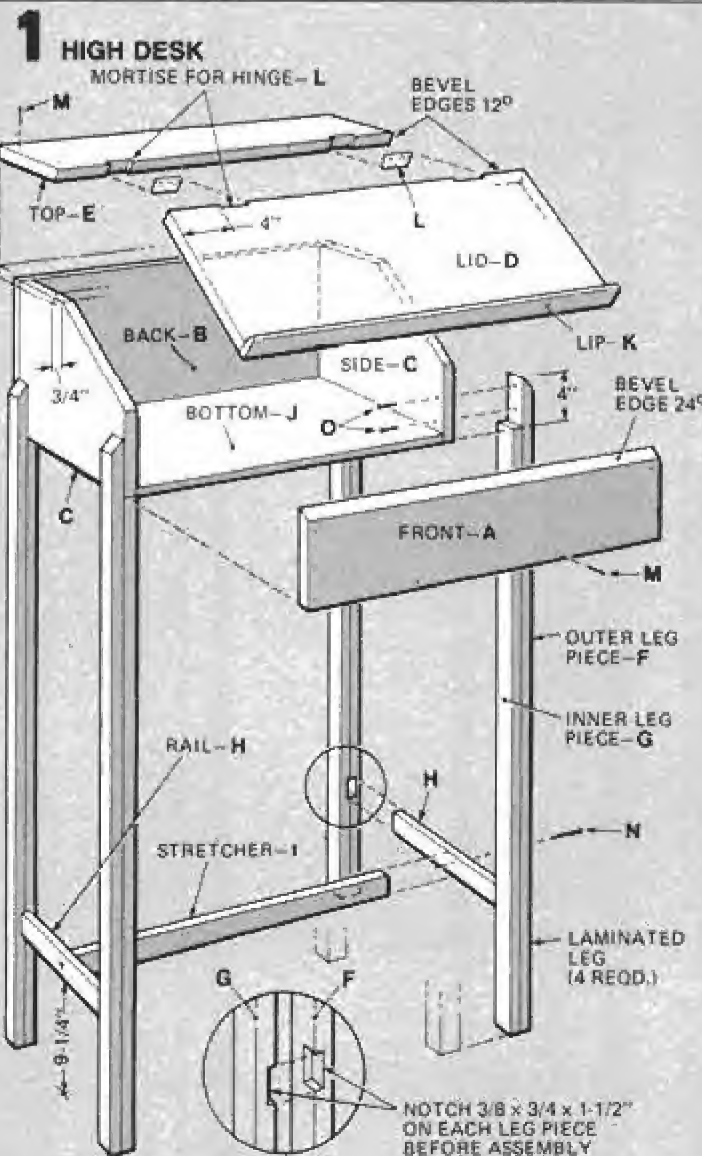
Assemble the box, using nails and

carpenter's glue. Work in an upright position and, once you have begun assembly, avoid excessive movement. Check again for square with your framing square, then hold the

# MATERIALS LIST—SMALL BENCH

| Key | No. | Size and description (use)                  |
|-----|-----|---|
| A   | 1   | 1/2" x 24" x 33" plywood (back)             |
| B   | 1   | 1/2" x 11 1/2" x 33" plywood (front)        |
| C   | 2   | 1/2" x 14" x 19" plywood (side)             |
| D   | 1   | 1/2" x 12" x 33" plywood (lid)              |
| E   | 1   | 1/2" x 2" x 33" plywood (cleat)             |
| F   | 1   | 1/2" x 13" x 33" plywood (bottom)           |
| G   | 2   | 3/4" x 1 1/2" x 13" pine (cleat)            |
| H   | 2   | 3/4" x 1 1/2" x 13" pine or hardwood (foot) |
| I   | 2   | 1/2" x 2" butt hinge                        |

Misc.: 8d finishing nails, carpenter's glue and paint.





box square, using a pair of diagonal braces temporarily tacked across the opposite corners. Use lattice strips or scrap for the braces.

Allow the glue to dry overnight, then set the nails and fill the holes with wood putty.

Finish the box by mortising for the hinges and installing the lid hardware.

Cut notches in the leg members to receive the rails. Insert the rails in the notches and glue the rails and laminated leg members together. To prevent the chance of twisted leg

assemblies, sandwich each assembly between large pieces of  $\frac{1}{2}$ -in. plywood. Be sure that the legs and rails are at  $90^\circ$  before clamp pressure is applied.

After the leg assemblies have dried thoroughly, attach them to the desk as shown, using screws and glue. The final step is attaching the stretcher to the legs with screws and glue. If all parts have been cut accurately, the assembly should produce a square desk.

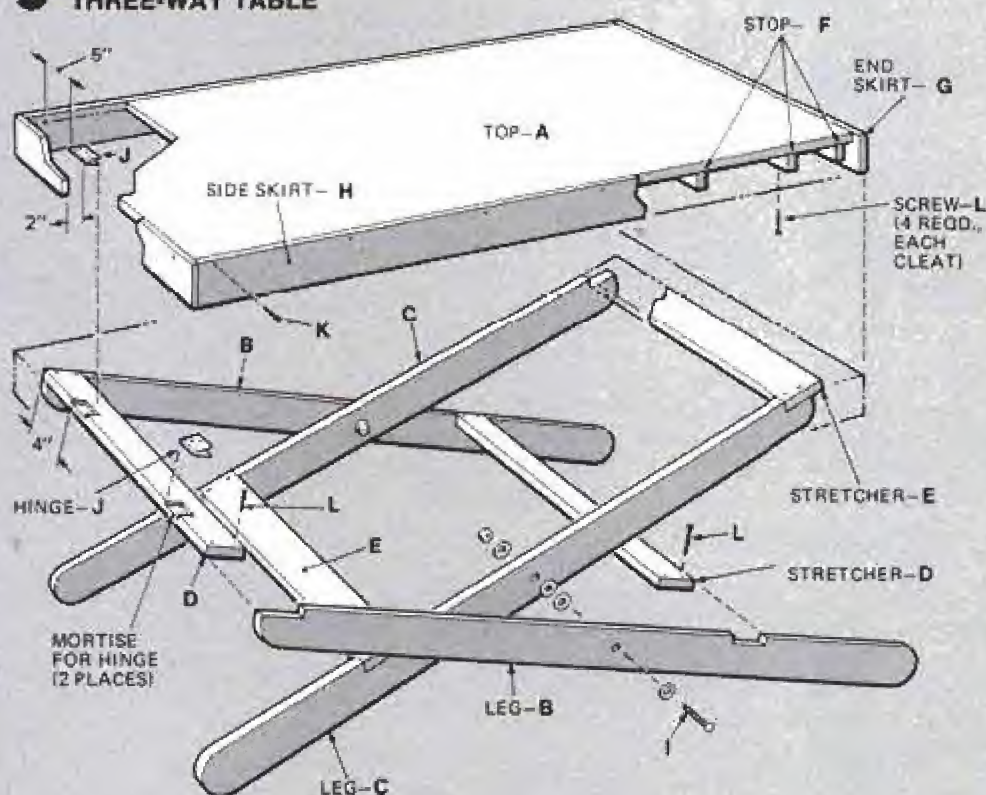
To finish, sand with 120-grit paper, dust off, then finish-sand with

# MATERIALS LIST—THREE-WAY TABLE

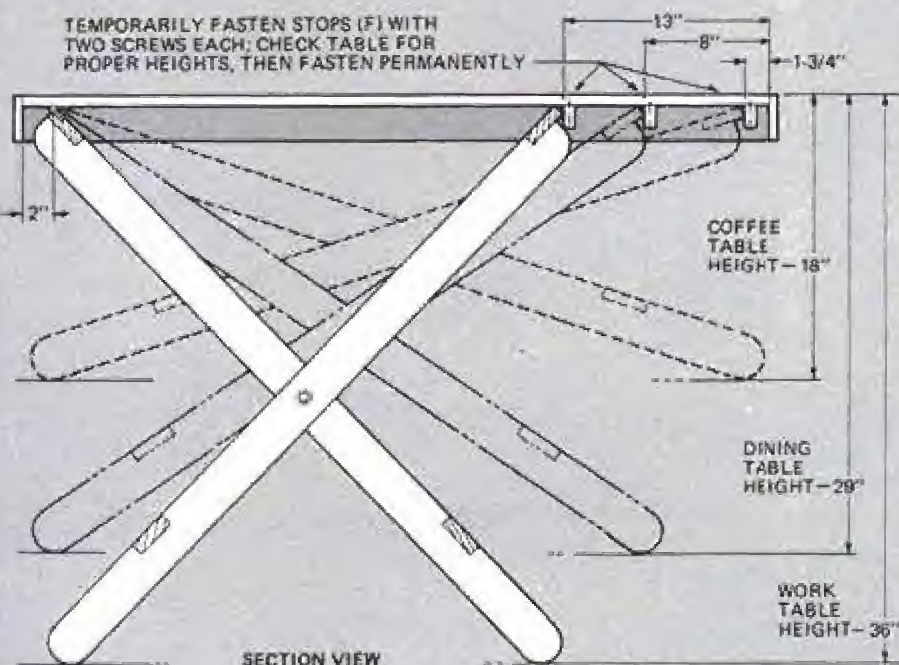
| Key   | No. | Size and description (use)  |
|-------|-----|---|
| A     | 1   | $3\frac{1}{2} \times 31\frac{1}{2} \times 47$ plywood (top)                     |
| B     | 2   | $3\frac{1}{2} \times 2\frac{3}{4} \times 47\frac{1}{2}$ redwood (leg)           |
| C     | 2   | $3\frac{1}{2} \times 2\frac{3}{4} \times 46\frac{1}{2}$ redwood (leg)           |
| D     | 2   | $3\frac{1}{2} \times 2\frac{3}{4} \times 29\frac{1}{2}$ redwood (stretcher)     |
| E     | 2   | $3\frac{1}{2} \times 2\frac{3}{4} \times 27\frac{1}{2}$ redwood (stretcher)     |
| F     | 3   | $3\frac{1}{2} \times 1\frac{1}{2} \times 31\frac{1}{2}$ redwood or pine (stops) |
| G     | 2   | $1\frac{1}{2} \times 3 \times 32\frac{1}{2}$ redwood (end skirt)                |
| H     | 2   | $1\frac{1}{2} \times 3 \times 47$ redwood (skirt)                               |
| I     | 2   | $\frac{3}{8} \times 2\frac{3}{4}$ rh. bolt                                      |
|       | 8   | $\frac{3}{4}$ -in. i.d. washer  |
|       | 2   | $\frac{5}{16}$ -in. hex nut   |
| J     | 12  | $\frac{3}{4}$ -in. 2" butt hinge $\frac{3}{4}$ -in. th screws                   |
| K     | 18  | 2" No. 8 th screws  |
| L     | 28  | 2" No. 12 th screws   |
| Misc. |     | Carpenter's glue, 100-grit sandpaper  |

(Text continues on page 236)

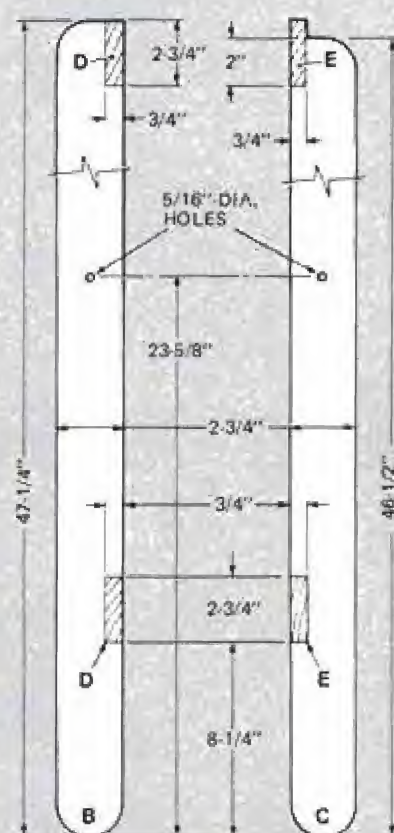
## 3 THREE-WAY TABLE



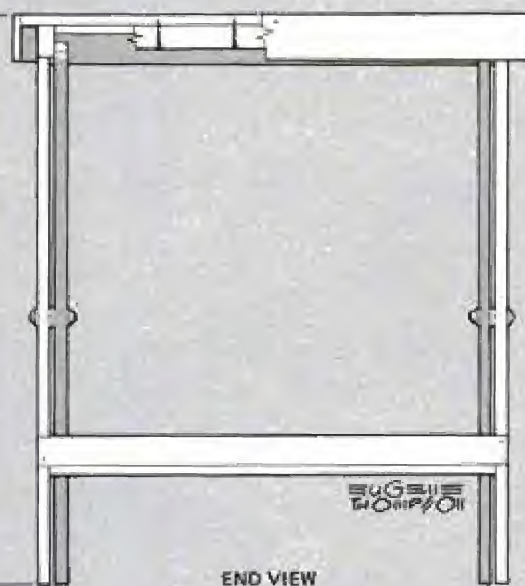
TEMPORARILY FASTEN STOPS (F) WITH TWO SCREWS EACH; CHECK TABLE FOR PROPER HEIGHTS, THEN FASTEN PERMANENTLY



SECTION VIEW



DETAIL OF LEGS B AND C



END VIEW



# TECH FRONT LINES

## The 1984 airship: Roomy, slow, easy to land—and cheap

The stately dirigible, once a symbol of poky but luxurious air travel, is coming back as a cargo-hauling workhorse.

If Britain's Redcoat Cargo Airlines follows through on its plans, a new breed of \$10 million airships will begin plying trade routes between the United Kingdom and West Africa in 1984. These craft will travel at a slow—and economical—68 knots. At the same time, U.S. designers are penciling huge ovals on their drawing boards, planning a role for dirigibles as giant cranes in the sky.

And one American company, Federal Express, has held preliminary talks with Airship about buying dirigibles to deliver packages in the late '80s.

The incentive is potential savings. With much of the lift provided by helium, airships may cut fuel costs by roughly a third.

It wasn't just the promise of higher profits that attracted Redcoat, a gutsy, 4-year-old company that hauls heavy machinery, racing horses, oil pipes, chemicals, baby chicks and other freight in turboprop planes (motto: "Redcoats are coming"). A couple of years ago, company directors decided the days of fixed-wing, cargo-hauling aircraft were numbered. Rising costs, they calculated, would ground the fleet in a few years. So they turned to another British firm, Airship Industries Ltd., which had been promoting lighter-than-air vehicles for a decade. During that period, it had corralled much of the world's airship-design talent.

Some of Airship's proposed aircraft resemble flying saucers—

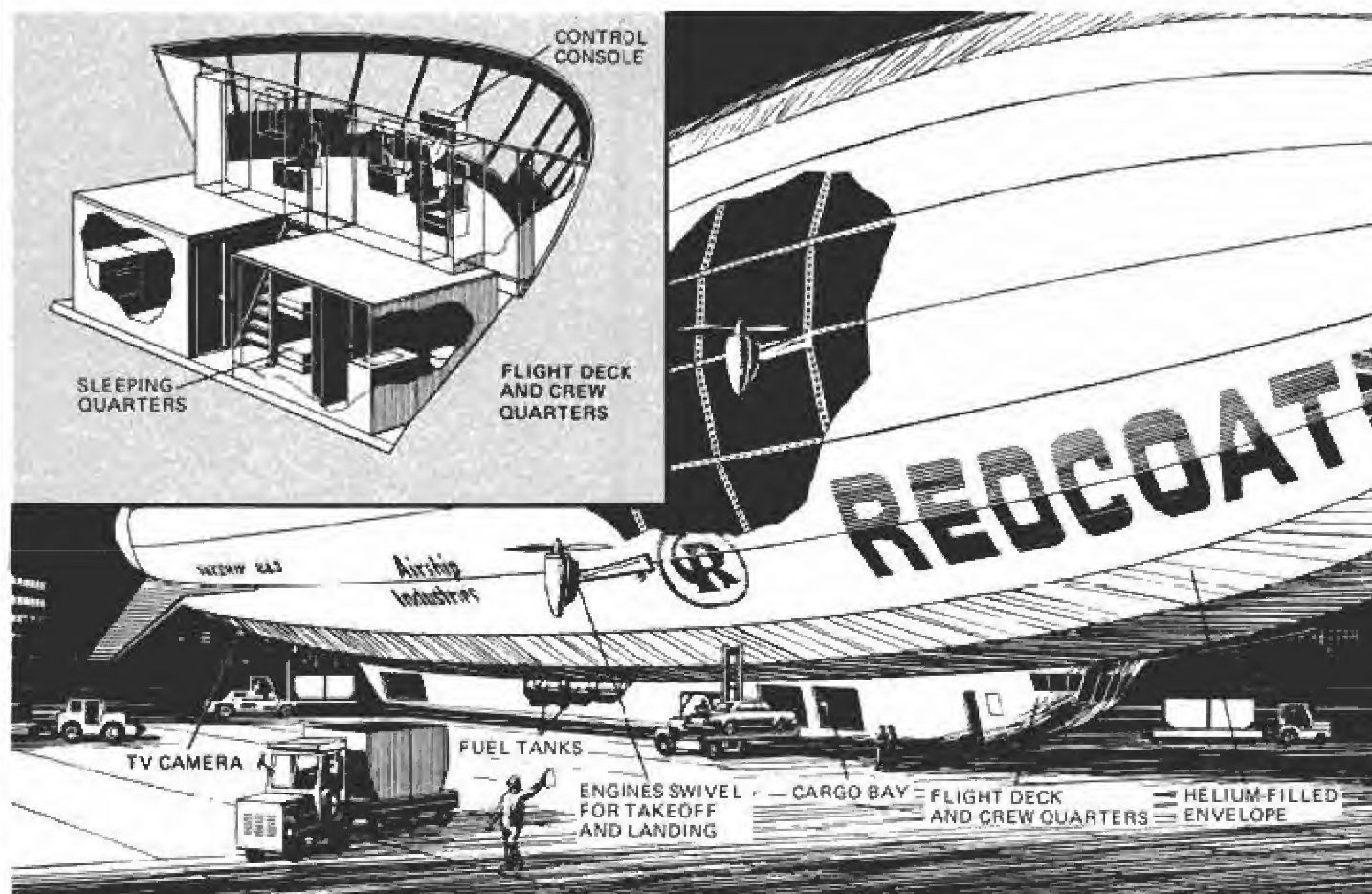
pillow-shaped ships with circular passenger quarters and engines thrusting out at each quadrant.

The firm is also in the process of completing several nonrigid "blimps" for offshore fisheries' surveillance. The first of these will fly in 1981. "The latter is an especially safe and sensible solution," says Malcolm Wren, chairman of Airship Industries, "when you consider that the U.S. Navy safely operated 160 airships in World War II for more than 20 million miles, with the

## AVIATION

only casualty coming from enemy action."

The rigid, metal-framed "R-150" airships ordered by Redcoat look more like traditional dirigibles. But the current models have capabilities that make the hydrogen-filled giants of the '30s look as antiquated as dinosaurs. "The old airships were notoriously underpowered and lacking in maneuverability," says Airship





Industries' chief designer, Patrick Monk. "A 1930s engine was unreliable and weighed perhaps three pounds per horsepower produced, whereas our turbines weigh only  $\frac{3}{4}$  pound per horsepower. Finally, we now know a lot more about aerodynamic design. We'll have a stronger, lighter, ship using new materials, such as Kevlar, and we'll carry state-of-the-art communications gear and weather radar."

Each of the new airships will contain some 4.5 million cubic feet of helium, and carry 40 tons of cargo 2,500 miles, or up to 58 tons for shorter distances. Powered by four turboprop engines, the 800-foot-long ship (200 feet shorter than Germany's *Hindenburg*) will reach West African destinations in about 2½ days.

Although slow in comparison to jet aircraft, the airships will reduce the typical ocean-going freighter's shipping time by more than 50 percent. And, in this hare-and-tortoise competition, the lumbering airships wind up beating jets in some respects. "The proposed R-150 airship should allow us to carry

U.K. exports overseas for at least 29 percent less cost than on narrow-bodied jet aircraft," says Kevin McPhillips, a founding partner of Redcoat. "And while it's true that a wide-body jumbo jet, such as the 747, can lift more weight than the R-150—all well and good for shipping something dense and heavy—our airship will have a cargo hold volume of nearly 38,000 cu. ft. That's 56 percent more space than the 747."

And unlike the 747—and dirigibles of the 1930s—the R-150 ought to be able to land almost anywhere. The turbine engines can be fully swiveled up or down, to allow vertical takeoff and landing. Engines on earlier dirigibles were fixed in position, necessitating a larger operating area. Redcoat's airships will be able to move cargo directly inland, close to customers' facilities.

## Giant weightlifter

Engineers in the United States agree that airships still have a place in the sky. Goodyear Aerospace Corp., for one, is doing a good deal more than lofting blimps over baseball stadiums. The Akron, Ohio, airship designer is working on nonrigid coastal patrol airships for the Naval Air Development Center. The company is exploring basic airship design in partnership with the National Aeronautics and Space Administration. And it's promoting an idea for a heavy-lift airship—a true flying crane—capable of transporting 75 tons. Helicopter rotors would supplement the lifting power of helium.

Goodyear has some competition on this crane idea from a small Philadelphia company, Piasecki Aircraft Corp. The firm has won a government contract to build an airship capable of lifting 26 tons and carting it 1,500 miles. The 340-foot-long dirigible is a hybrid, like Goodyear's weightlifter. Four Sikorsky H-34 helicopters are connected by an aluminum frame to the helium-filled envelope.

Only one of the helicopters—the one to the left and rear of the envelope—contains the crew, a pilot and copilot. The other choppers are drones, linked to the command ship. They maneuver the ship over the cargo after it



Piasecki's hybrid: new log lifter.



Airship envelope nears completion.

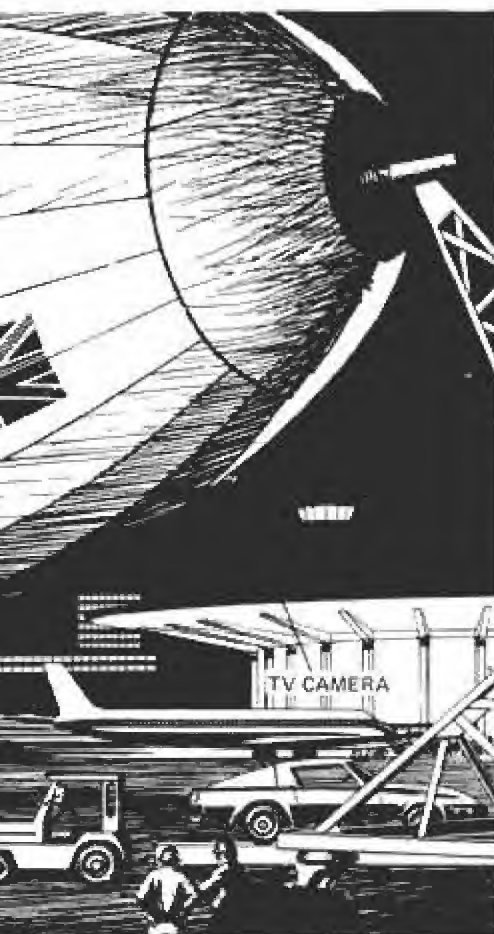
cruises to the site at about 65 knots.

This extraordinary airship, approaching completion at the Lakehurst, N.J., Naval Air Engineering Center, is slated for action in the Pacific northwest.

Again, the promise of substantial savings is keeping the airship idea aloft. Road-building costs for logging operations are approaching \$150,000 per mile. So the U.S. Forest Service is open to new—even old—ideas. Piasecki's \$10.5-million "Heli-Stat" is expected to cut almost 40 percent off the cost of aerial timber harvesting as currently done by helicopter.

Company officials tell PM that their weightlifter ought to be able to handle assignments hauling materials to construction sites or lowering bridge components into place. It could also compensate for a growing problem at ports around the world: There aren't enough cranes to load and unload cargo.

Shortly, the latest hybrid airship, buoyed by an inert, harmless, lightweight gas, may become a heavy-duty stevedore at major ports around the world.





## ENERGY

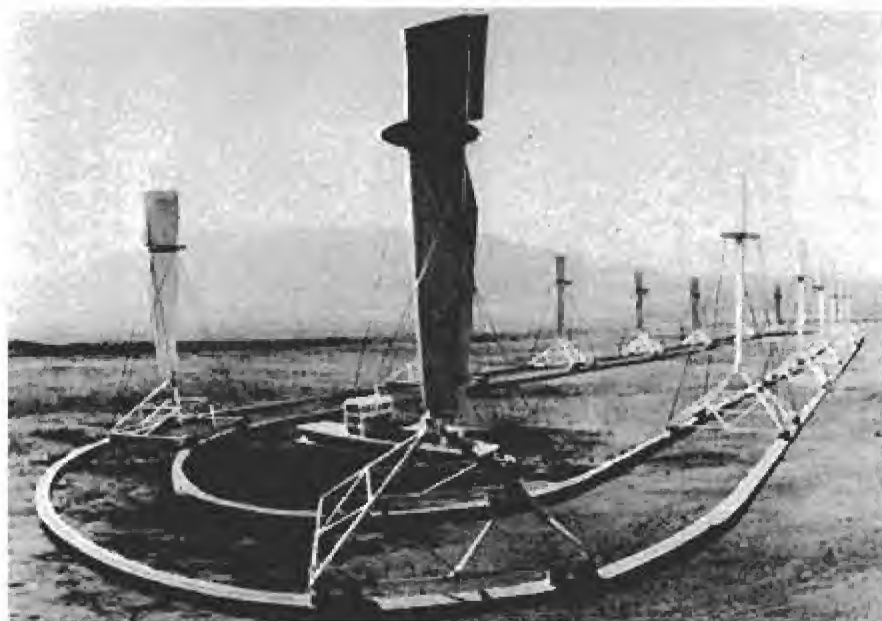
### Winging the wind

The railroad envisioned by Utah inventor Laird B. Gogins won't go anywhere and it won't cart any passengers. But if it works, it will deliver enough electricity for thousands of households without burning a drop of oil or a lump of coal.

Like giant mechanical sharks with fins thrust high, 14 railroad cars will chase each other around a half-mile oval track at Point of the Mountain, a windy site located 20 miles south of Salt Lake City.

Each of the tetrahedron-shaped cars, 93 feet wide and 50 feet high, will support a giant aluminum airfoil—the shark's fin—designed to catch wind. The 200-foot-high airfoils will be adjusted to get maximum efficiency as they move. The cars will be able to withstand gusts of 80 mph. Gogins says that the area's average wind speed of about 18 mph will move his cars at more than 25 mph. Wheels on the cars will drive electrical generators that feed power through brushes into rails.

How much energy? Gogins claims the wind-blown cars will put out approximately 175 million kilowatt hours per year—



Gogins's "free-wing turbine" would run on wind at site near Salt Lake City. Generators in computer-controlled cars would feed power through the tracks.

enough to supply about 20,000 households.

The basic idea isn't new. For decades, inventors have sought ways to capture energy from flat-bed railroad cars driven by sails, rotors or airfoils. But Gogins says his "free-wing turbine" will outperform any previous design. He's already lined up a customer, the Western Area Power Administration, which has agreed to buy his power if he can produce it at a competitive rate.

"The concept is viable, theoretically," a Western spokesman tells us. "The basic idea is proven: It's the principle behind sailboats. Whether he can keep his 'boats' going around in a circle all the time, I don't know."

### Perils of invention

Gogins is accustomed to tough odds. A few years ago, in an attempt to invent the world's fastest sailboat, Gogins mounted a 220-sq.-ft. wing on a modified Flying Dutchman. He set out with a friend on the chilly waters of Great Salt Lake. The boat capsized 1½ miles from shore and the two men had difficulty clinging to the glistening bottom. Gogins had worked hard to smooth out for speed. Winds were so high that it took more than 1½ hours for a rescue boat to get to the men. When Gogins got to a hospital, his body temperature was 86°. Despite the experience, he

remains convinced that airfoils can be used to power pleasure boats as well as cargo ships.

He's also sure he can draw the \$23 million he needs to build the land-based powerplant. He says that he has already had encouraging discussions with several New York investment houses.

### Target: 1985

One selling point, he says, is the comparatively short time required between breaking ground and generating power. If construction begins as planned late this summer, Gogins estimates the kilowatts will begin flowing in about four years. A nationwide system of free-wing turbines could become operational in a dozen years, he says. By comparison, a single nuclear powerplant now takes 13 years to come into production.

While Gogins goes after the financing, a small version of the device, built with 32-foot-high wings, is already sailing. The inventor plans to lease such miniature wind-powered railroads to farmers and water districts to power their irrigation pumps.

And the man who almost drowned in Great Salt Lake while one of his foils wallowed in water isn't one to ignore the lessons of experience. He's hard at work on an underwater version of the free-wing turbine that will draw power from tides and currents.



Puerto Rico's Center for Energy and Environmental Research is testing this solar collector, a jawlike set of tubes. Each tube protects a reflective strip, bouncing the sun at fluid that runs between collector "jaws." The Center's focusing device could be marketed for \$10 a square foot, which is comparable to the cost of less-efficient flat-plate collectors.



## PRODUCTS

### Radiation alarms

Radiation detectors, from Solar Electronics (156 Drakes Lane, Summertown, Tenn. 38483) combine features of a Geiger counter with those of a radiation alarm.

The Nuke Buster (\$279) plugs into cigaret-lighter sockets; it can also draw power from an optional battery pack or an a.c. adapter. It can be set to sound an alarm when radiation rises to 10, 100 or 1,000 times normal background. A meter provides a continuous readout in milliroentgens per hour.

The company also offers a handheld radiation detector without the meter for \$199.

### Heat pump for water

Can you use some of the warmth in your basement or garage to help heat your home's water? A Tennessee Valley Authority (TVA) report suggests you can—and you can also save an average of 57 percent on your hot-water energy bill.

The Efficiency II heater (from E-Tech Inc., 3570 American Dr., Atlanta, Ga. 30341) is a heat pump which absorbs energy from ambient air and releases it into water (see diagram below).

Like other heat pumps, the Efficiency II works like a refrigerator in reverse. A fan draws room air over a coil, evaporating a refrigerant and absorbing heat. A compressor further increases the temperature of the refriger-

ant. Heat is absorbed by water in a heat exchanger, where refrigerant vapor condenses back into a liquid.

The TVA study—which was based on a small sample of its customers—indicates that the pump would pay for itself in about 5½ years, based on a price of about \$700. Installation adds \$50 to \$150 to the cost.

A bonus: The device, which hooks up to a standard hot-water heater, cools and dehumidifies in summer. A caution: The Efficiency II loses efficiency if the temperature of your basement falls below 50° F.

### Stop that scratch

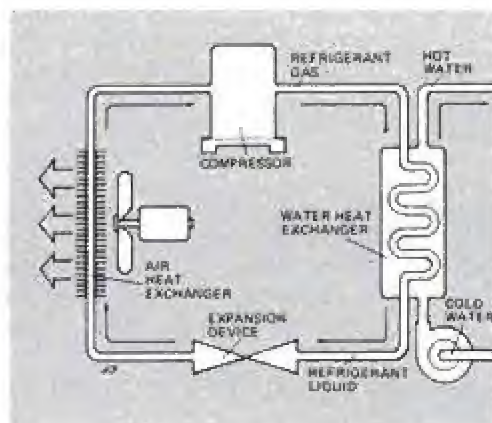
Both lenses in the plastic eyeglasses below were rubbed with steel wool, which would normally cloud the view irreparably.

But one lens (at right) shows no



Treated right-hand lens stays clear.

trace of scratching. It was coated by a special process developed by Armorlite Inc., a subsidiary of 3M. The antiscratch armor (\$15 to \$25 extra when glasses are ordered) is a coating made from a silicon compound and a metal ester.



In Efficiency II, water absorbs heat from refrigerant warmed by inside air.

## INVENTIONS

### Electronic exercise

A newly patented stationary bicycle keeps track of your pulse and work output, and warns if you're overexercising.

The user clips a pulse-rate monitor on one ear and sets a pedal speed and maximum heart rate. The bike (Patent 4,244,021) records kilopond meters per minute. (A kilopond meter is the amount of work required to lift one kilogram one meter.) Alarms are triggered if pedaling slows or heart rate exceeds preset limits.

The inventor, Robert E. Chiles III, is an electronics engineer with AMF Inc., which markets the Computrim 900 for about \$1,000.

### Radiation saves art

A New Yorker has found a way to strengthen and preserve works of art made of organic materials such as canvas, wood or leather. Ioan G. Crihan was granted Patent 4,246,295 for his method of protecting tapestries, paintings, carvings and valuables.

The object is subjected to a vacuum, impregnated with an unsaturated resin, and exposed to radiation. The cured resin forms a binding agent and the radiation destroys insects, worms, molds, mildew, spores and fungi that threaten the art.

### Sea-B communication

In the past, sane people who have tried to talk with dolphins, porpoises and whales have met with limited success.

Now, a new system aimed at getting through to intelligent marine mammals has been developed by Stephen and Charles Cooper. They've constructed an alphabet of 18 symbols, each a combination of three-dimensional, postlike shapes. Humans can "read" these shapes visually and marine animals can perceive them using their sonarlike system of echolocation.

The U.S. Patent Office liked the idea enough to award Patent 4,245,587. So far, no word from the whales.





## AUTOMOTIVE

### Slippery single-seater

This summer, Aerovisions Inc. of Irvine, Calif., hopes to begin producing one of the world's most practical and fuel-efficient single-seaters—the 155-mpg California Commuter.

Designer/developer Doug Malewicki recently drove a prototype from Los Angeles to San Francisco along the tortuous coast highway, U.S. 101. He averaged 157.19 mpg, despite less-than-ideal driving conditions and numerous stops for press interviews and photographs. His speed was just under 55 mph.

The California Commuter is legally classed as a motorcycle. The engine is an enlarged Honda 90, with manual clutch, four-speed gearbox, and chain drive to the single, drum-braked rear wheel. The two front wheels steer and have disc brakes. Motorcycle driving controls include handlebars, twist-grip throttle, hand clutch, right-foot braking, and left-foot shifting.

There's room for only one person inside the highly aerodynamic fiberglass-and-foam body, and the driver sits in a semirecumbent position. Cornering stability and resistance to cross-



In a test run from Los Angeles to San Francisco along winding coast roads, \$4,000 California Commuter got 157 mpg while averaging just under 55 mph.

winds is said to be excellent in this three-wheeler.

Early tests with a modified 10.5-hp Honda engine registered a top speed of 82 mph and 0 to 60 mph in 15.3 seconds. For the Los Angeles-to-San Francisco run, the engine was bored out to 133 cc and checked on the dynamometer at 15.5 horses. Top speed is now estimated at 90 to 95 mph, with 0 to 60 in 12.5 seconds.

Aerovisions plans to produce 500 copies of the California Commuter at a base price of \$4,000. A 200-cc engine with electric starter is optional. If the single-seater

is a financial success, Aerovisions will introduce the Commuter II, a three-wheeler that can hold two adults.

For a technical booklet, send \$3 to California Commuter, Aerovisions Inc., 14962 Merced Circle, Irvine, Calif. 92714.

### Fresh start

Recently, BMW engineers have proposed that manifold vacuum gauges sometimes mislead drivers about fuel efficiency. And research by the West German company confirms that brisk acceleration saves more fuel than *pokey start-ups* (see *Driving for Economy*, page 109, March '80).

BMW took us on two 0 to 60 kilometer-per-hour runs on the company's test track near Munich. In the light-footed takeoff, the 745i used 83 cc of fuel after 500 meters. A vacuum gauge stayed in the green, indicating efficient driving. Next, driver Gregor Fischer ran through the same 500 meters with a fast, almost jumpy start. Consumption dropped to 71 cc, while the vacuum-gauge needle swung into the red.

BMW's prescription: Accelerate briskly, pushing the pedal three-quarters of the way to the floor. And shift early, at about 2000 rpm. The engine shouldn't roar like a lion. But the whole pattern does distinctly resemble the oft-maligned jack-rabbit start.



Germans trying to preserve a showroom look go to Guenter Artz of Hannover, West Germany, who wraps up

and stores new cars like heads of lettuce. His scratch-prevention, paint-protection services cost \$50 a month.



## ELECTRONICS

### Routing out the sound

A lot more sound gets piled into record grooves these days than ever before. So cartridge designers have had to come up with new models capable of coaxing all the sound from these new discs.

The problem is that today's records, with their expanded range of volume, require the stylus to wiggle at far higher velocities than ever before. Extra stress is focused on a vulnerable point: the tip of the stylus. Here the grandeur of a symphony is shrunk to the dimensions of a fly-speck.

If Isaac Newton were to analyze the happenings in the record groove, he would immediately point out that anything that has to wiggle that fast—navigating some 20,000 hairpin turns per second—must be very light. Otherwise, too much inertia develops and the stylus either overshoots the curves or cuts across them.

For a while, the effort to lose weight had cartridge designers in a bind. Since the weight of the diamond tip is fixed by its dimensions and can't be reduced, other

### Multilingual ring

Nothing is constant. Even the familiar ring of the telephone changes from country to country.

In the Middle East, the phones ring continuously until they are answered or the caller gives up. Socially conscious phones in France sound different in the city than they do in the country.

So, many countries have not been in the market for American switchboards with their unchangeable Yankee accents.

Times have changed. Western Electric has unveiled its new Call Progress System. One of this system's features is that it can produce rings and buzzes in any cacophonous combination to fulfill any culture's telephone requirements. The user can program 74 microprocessors to serve one country and then alter them for another set of guidelines.

Now America can ring all the world's chimes.



Video is challenging the home movie market, as demonstrated by this prototype from Hitachi. The portable

combines a color videotape recorder with a color camera. It can be operated to play back as well as record.

ways had to be found to lessen the stylus mass. So engineers concentrated on the shank: the tiny lever linking the diamond tip with the magnetic innards of the cartridge. They tapered the shank to make it lighter near the tip where the swing is widest, but this weakened the shank. The thinned-down shanks bent and flexed under fast vibrations. As a result, the highs were not faithfully transmitted to the cartridge from the stylus tip.

So, audio engineers tried materials and techniques borrowed from space technology. Audio Technica, for example, now makes stylus shanks of beryllium, the metal with the highest strength-to-weight ratio.

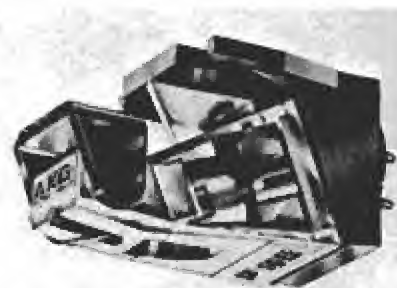
Others offer stylus shanks of thin-walled aluminum reinforced by miniature beryllium rods located inside. And some manufacturers use high-strength carbon fibers for their stylus.

As a result of these efforts, the dynamic mass of cartridges—that is, the total weight of their moving parts—has been drastically lightened. In many of the better models, it is now less than 1 milligram.

The audible benefits of these

advances are cleaner highs, more lucid texture during peaks, crisper percussion, and more realistic thuds and wallops down in the bass.

Luckily, benefits of these developments have already filtered down to recent models in the medium-price range. For example, Shure's M-97-HE (\$112) incorporates nearly all the advanced features stemming from this research, as does Audio Technica's AT-120E (\$90). AKG's Model P8E (\$115) and ADC's



AKG P8E: tracks fast, low mass.

KLM-III (\$110), as well as Empire's 500ID (\$125) have newly designed stylus pivots which contribute greatly to clarity and transient response.

All of these lightweight, new cartridges benefit from radically reduced dynamic mass. So audio sound today has a better chance than ever of passing through the narrow pass at the stylus without being ambushed en route to the amplifier.

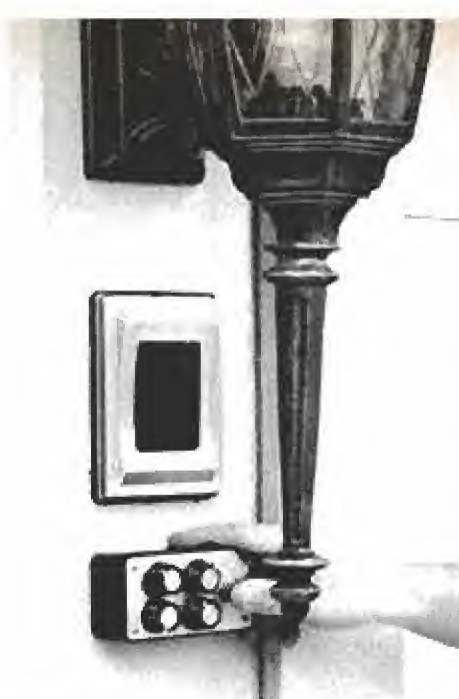
Editor: Gurney Williams III

Contributors: Tony Assenza, Jack Carroll, Hans Fandel, Stacy V. Jones, Michael Lamm, Neil Shapiro, Steve Warren

100  
100  
100



# Make this electric garage-door lock



To open the garage door, turn four knobs to proper positions and press the button.

**T**his combination lock for a garage-door opener lets you activate the opener at the touch of a button without using easy-to-lose keys or magnets. I made it for under \$10 in less than 30 minutes.

You can purchase the components at an electrical supply house or from a Radio Shack store (see parts list, below). You'll need a drill, screwdriver and soldering iron.

To make the opener work, you must complete an electrical circuit through four 12-position rotary switches and a momentary-contact pushbutton switch; then press the pushbutton switch that is normally open. You must know the correct position of all four rotary switches.

You can attach the device to the front of your garage or in another convenient spot. For additional safety, you might add a tamper switch that sounds an alarm if the box is removed.

To begin assembly, lay out the positions of the four holes for the rotary switches and the hole for the pushbutton on the cabinet. Allow a minimum 1½-in. space between centers. Bore ¼-in.-dia. pilot holes; bore ½-in.-dia. holes for the rotary switches and a ½-in.-dia. hole for the pushbutton. Feed the drill slowly to prevent grabbing or denting the aluminum face.

Install the rotary switches and pushbutton switch. Tighten the nut provided with each switch.

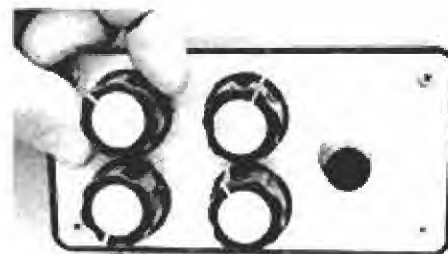
As a first step in wiring, solder a 2-in. piece of insulated wire to the center lug of the first rotary switch. Then solder this wire to any of the outside lugs of an adjacent rotary switch. Repeat this process for the second, third and fourth rotary switches. The fourth switch should be located next to the momentary-

contact switch. With a 2-in. piece of wire, connect one of the outside lugs of the fourth rotary switch to a lug of the momentary-contact switch.

Strip two 2-in. pieces of insulated wire and solder the end of one piece to the remaining lug of the momentary-contact switch. Solder the remaining piece of insulated wire to one of the outside lugs of the first rotary contact. These short pieces of wire connect to the low-voltage wiring from your door operator.

Using bolt cutters, snip off the excess shaft supplied with the rotary switches. Install the knobs by sliding them over the shafts and tighten the mounting screws. Rotate all knobs so they point to the 12 o'clock position. Scratch or etch a mark on the faceplate above each knob. Then rotate each knob one click and repeat the process until the 12 positions have been marked.

To figure your combination, while



Knobs rotate to predetermined position.

facing the back of the panel, rotate each knob until the center wiper contact inside each switch is aligned with the terminal of the rotary switch that has been soldered to the wire. With all four switches aligned, note the position of each knob on the face of the panel. This is the combination of your lock.

By using any of the 12 positions on each rotary switch, any combination is possible. Prior to installing the combination lock, check continuity with an ohmmeter, if you can.

Carefully plan the installation position of the lock on the outside of your home or garage. Select a spot that provides some weather protection, or shelter it in a wooden box.

Mount the box securely to the garage by boring its back in three locations and securing it to the wall with sheet-metal screws. Next, bore a ⅝- or ½-in.-dia. hole through one side of the box and garage wall to permit the bell wire from the ga-

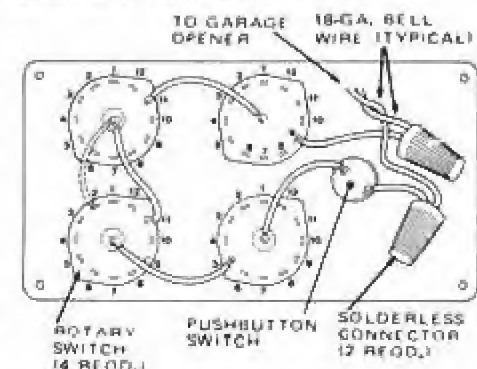
rage-door opener to be pulled into the box.

**Note:** To prevent accidental operation or electrical hazard while wiring, disconnect the power at the circuit breaker or unplug the garage-door opener from the connection to the house power supply.

Install the bell wire between the combination lock and the low-voltage contacts of the garage-door opener. Most have a two-screw terminal, so a doorbell button can be used from indoors to operate the door. Connect each wire to a screw on this terminal, tightening screws *securely*. Pull the other end of the bell wire into the combination-lock box, leaving 6 in. exposed. Connect the two short pigtailed from the switches to the two ends of the wire, using solderless connectors. Test and install the faceplate. Rotate switches after use.—Thomas A. Gauldin



Wire the rotary and pushbutton switches. Use solderless connectors to connect the switches to the garage-door opener.



Combination is now 5-11-11-9. Proposed change (dotted wire) would be 5-2-11-9.

## PARTS LIST—ELECTRIC LOCK

| Am't. | Description  |
|-------|--|
| 4     | Mallory No. 382 templates numbered 1-12 (optional) |
| 1     | Archer No. 270-233 mini-utility box                |
| 4     | Archer No. 275-1385 12-position rotary switches    |
| 1     | Archer No. 275-609 pushbutton switch               |
| 4     | Archer No. 274-416 1" molded knobs for ¼" shaft    |
| 1     | 18-ga. insulated bell wire (length to suit)        |
| 1     | door operator                                      |
| 2     | solderless connectors                              |
| 3     | No. 8 × 1½" sheet-metal screws                     |



1981 Popular Mechanics

# CAR CARE GUIDE



PM photo: David Pruitt

## 50 MOST COMMONLY REPLACED PARTS OF YOUR CAR

This ninth annual Car Care Guide focuses on the 50 most commonly replaced parts of your car. Since these 50 parts eat up the biggest part of your maintenance budget, you'll save a bundle if you do it yourself...and we'll show you how.

**Plus: The tools you'll need to do the job right.**

The computers are here and we'll show you how to troubleshoot GM's new Computer Command Control, and take a look at how auto computers will change the look of your dashboard.



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1981 Popular Mechanics

# CAR CARE GUIDE

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**THE TOOLS THAT KEEP THE WHEELS TURNING**

**DOMESTIC AND FOREIGN CAR RECALLS**

Prepared by the editors of Popular Mechanics with technical art by Dale Gustafson, Fred Wolff, Jeff Mangiat, Ed Lipinski, Hank Iken and Mike Terris. Photos by David Pruitt. Car Care Guide designed by Don Mannes.

## When Should YOU Change Engine Oil?

How you drive determines how far and how often you should change your crankcase oil. It is nearly impossible to drive a car properly so that yearly changes of oil would be safe for your engine.

Traffic jams, winter warm-ups, short runs, taking kids to school, and those short trips to the store all tend to shorten the life of your oil.

On top of that, today's engines are smaller, work harder and run hotter. All of these things help foul up engine oil, create varnish, gum and sludge as they use up the additives in the motor oil.

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# AUTO MAINTENANCE IS MORE IMPORTANT THAN EVER!

Exotic gizmos we never dreamed of 30 years ago are popping up under your hood. But fixing the cars of the '80s can be as easy as falling off a microprocessor.

**1957 Chevrolet Belair**



The 1957 Belair (left) came with the rugged Chevy small-block V8. Although more sophisticated and refined, the same block is still around and no mystery to the Saturday mechanic.

The '67 Pontiac Bonneville (right) may have had lots of brute horsepower but fell short in the brakes. Servicing front brake drums was a real chore.



**1967 Pontiac Bonneville**

Vertical-flow radiator of the 1958 Rambler (below) was less efficient than modern cross-flow radiators. The newer ones are also easier to service.



**1958 American Motors Rambler**



**T**wenty years ago, Chrysler Corp. became the first major United States car manufacturer to install alternating-current generators (called alternators) on cars. At the time, many Saturday mechanics wrote to tell PM's *Car Clinic* that the alternator was a development signaling the end of do-it-yourself auto maintenance and repair. These people—adept at maintaining, troubleshooting, disassembling and overhauling direct-current generators—viewed the alternator as a threat to their self-sufficiency.

For one thing, the alternator didn't have the familiar oil cup through which they diligently applied oil every 4,000 or 5,000 miles to lubricate the bearings. Neither did alternators have an external nut on the pulley which, when unscrewed, allowed them to remove and inspect each generator component from the front end plate back to the brush end plate.

"How the heck does this thing (meaning the alternator) come



**1954 Chevrolet hardtop**



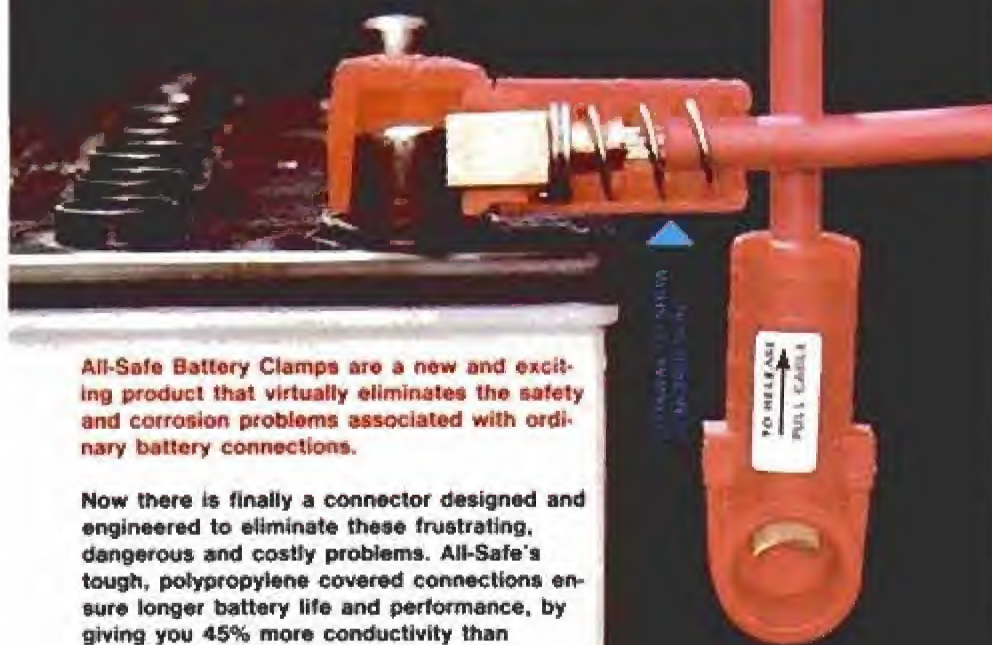
**1955 Chevrolet convertible**

The d.c. generator of the '54 Chevy (top) had to be lubricated often. Alternators did away with lubing. Remember vapor lock? If you owned a '55 Chevy (above) you probably got stuck more than once. With modern fuel systems, that problem is unheard of.





# THE ULTIMATE CONNECTION



All-Safe Battery Clamps are a new and exciting product that virtually eliminates the safety and corrosion problems associated with ordinary battery connections.

Now there is finally a connector designed and engineered to eliminate these frustrating, dangerous and costly problems. All-Safe's tough, polypropylene covered connections ensure longer battery life and performance, by giving you 45% more conductivity than conventional lead terminals.

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- Easily removed when necessary.
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- Cannot be cross connected.
- Completely covers post, no shorts or arcs
- Cover is filled with anti-corrosion gel.
- Heavy duty copper cable to match load requirements.
- Special clip for safe jumper capability.

Corrosion results in loss of transmitted power, unreliable performance and reduces battery life. Loose connections, poor contact and exposed battery posts are also potential fire hazards.

Say good-bye to battery connection problems for many years to come. Order a set, try them. You'll want them on all your vehicles. Immediate delivery, direct from the factory.



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State \_\_\_\_\_

Zip \_\_\_\_\_

Car Make \_\_\_\_\_

Model \_\_\_\_\_

Year \_\_\_\_\_

Engine \_\_\_\_\_

apart?" many PM readers wanted to know. (If you refer to the 1964-66 issues of PM, you'll find that we told them.)

Nor did the alternator have the familiar parts of a generator; that is, the armature, field coils and brushes.

"What in the world are rotors, stators and diodes?" letters addressed to *Car Clinic* asked.

Many of these Saturday mechanics worried that with the purchase of their next car they would have to hang up their tools and turn the vehicle over to "specialists" for repair. Well, it hasn't turned out that way. Those who wouldn't let the Saturday mechanic become an endangered species boned up on alternator (and other) technology, getting much of their information in the pages of PM.

The alternator is only one example of the revolution in automotive technology which has taken place since the 1950-60 era. The list is long, including electronic ignition, sealed fuel pumps, lubed-for-life ball joints, maintenance-free batteries, sealed carburetors and computers.

Our readers have been meeting this challenge. Instead of an increasing number of Saturday mechanics being put out to pasture, more car owners than ever are becoming Saturday mechanics. More are doing their own work, and there's a greater amount than ever for the Saturday mechanic to do.

If you don't believe this, compare some of the shop manuals of the past with those of today. Just the size of present manuals is enough to overwhelm you. For example, the manual covering all the 1955 Ford models is 341 pages long; the shop manual for the 1980 Ford Escort (only one model) contains 625 pages.

Like the coming of the alternator, pollution-control devices caused chagrin before they were understood and "conquered" by the nonprofessional mechanic.

What's next on the list of challenges for the Saturday mechanic? Electronics, in a word—specifically, the sophisticated computer GM has installed across the board in 1981.

While the thought of working on a computer may seem overwhelming; almost impossible, ultimately it won't be any more complex than working on pollution-control devices. Of course, you'll have to be equipped with the information that allows you to perform the necessary maintenance.

Because of this increasing, but accessible, complexity of new-generation engines and controls, and the increasing cost of skilled labor to maintain these powerplants, it becomes vitally important to the Saturday mechanic to stay on top of these rapid changes.

We might mourn the passing of the rugged, simple mechanical systems of the past, but, we bet, quicker than you can say silicon chip, you'll be able to master any new piece of hardware that shows up under the hood.

PM



# May is CAR CARE MONTH

**Joseph B. Mittelman**  
Chairman of the Board,  
AUTOMOTIVE PARTS &  
ACCESSORIES ASSOCIATION

This year represents the ninth consecutive year that POPULAR MECHANICS and APAA have co-sponsored "May is Car Care Month." The goal of this national program is to educate car owners in the proper ways of car maintenance. And, in the process, to make them aware of the auto care products that can help keep their cars running smoothly and efficiently.

Newspapers throughout the country are doing their part by publishing Car Care Month sections during the month of May.

The cooperating Manufacturers listed on this page offer the products that can keep your car in peak condition and contribute to energy savings.

On pages 142 and 143, you will find the APAA - member Retailers featuring these and other car care products, plus helpful hints that enable you to "DRIVE A HAPPY CAR."

**APAA**  
**AUTOMOTIVE**  
**PARTS & ACCESSORIES**  
**ASSOCIATION**  
**Popular**  
**Mechanics**

## MANUFACTURERS

**ANCO**

Anco Windshield Wipers

**bondo**

Bondo Body Filler

**CHAMPION**

Champion Spark Plugs

**CHILTON**  
Book Company

Auto Repair Manual 1981  
Repair & Tune-up Guides

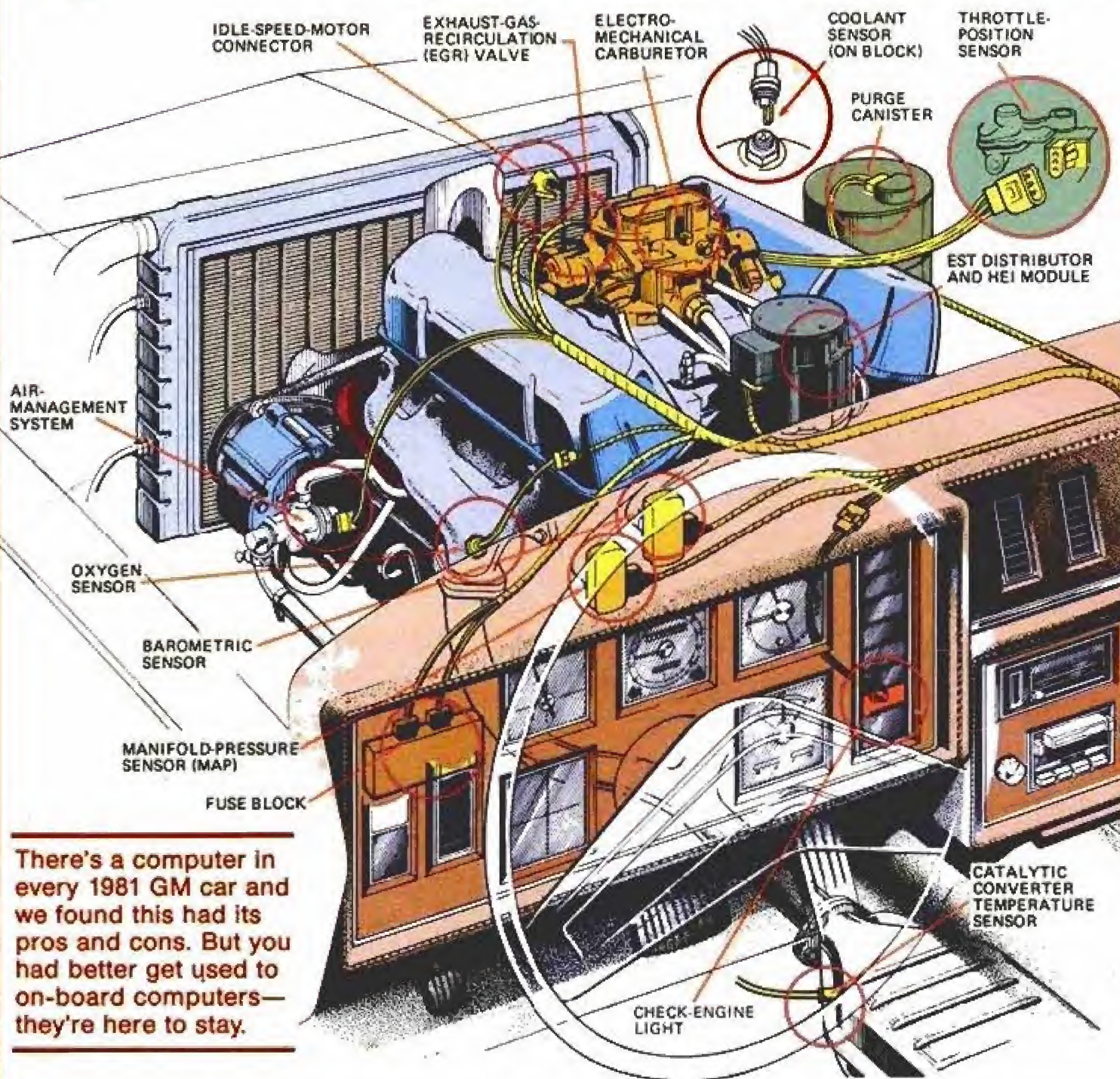
**FRAM**

Fram Oil Filter  
Fram Extra Life Air Filter  
Autolite Sparkplugs

|                             |   |
|-----------------------------|---|
| <b>gojo</b><br><b>SWISS</b> | Go-Jo Heavy Duty Hand Cleaner<br>Swiss Snowite Lite 'N Easy Body Filler   |
| <b>GOLD EAGLE</b>           | Power Steering Fluid<br>Brake Fluid   |
| <b>GUMOUT</b>               | Jet Spray Carburetor & Choke Cleaner  |
| <b>HAYDEN INC.</b>          | Electra Swirl Fan<br>Thermal Fan Clutch   |
| <b>Kendall MOTOR OIL</b>    | Superb 100 Motor Oil  |
| <b>Motorcraft</b>           | Motorcraft Oil<br>Spark Plugs<br>Oil Filters<br>Batteries<br>Wire Sets<br>Tune-up Kits  |
| <b>PEAK</b>                 | PEAK antifreeze & coolant   |
| <b>QUAKER STATE</b>         | Quaker State<br>Sterling Motor Oil<br>DeLuxe Motor Oil<br>Super Blend Motor Oil<br>HD Motor Oil<br>Oil Filter<br>Air Filter   |
| <b>SHALER</b>               | Raisone   |
| <b>STP</b>                  | Oil Treatment   |
| <b>turtle wax</b>           | Polysheal One Step Liquid<br>Polysheal One Step Paste<br>Polysheal System<br>Polysheal Fabric Upholstery Protector<br>Color Back Finish Restorer<br>Turtle Extra Liquid Wax |
| <b>VALVOLINE</b>            | All-Climate Motor Oil<br>Automatic Transmission Fluid<br>Gas Booster<br>Diesel Fuel Conditioner<br>Power Steering Fluid<br>Oil Filter                                       |
| <b>VIGOR</b>                | Super Eyes-The Micro-Computer Reverse, Anti-Collision car device  |
| <b>wynn's</b>               | Power Steering Fluid<br>Spitfire Gas Treatment<br>Engine Tune-up  |



# GM'S COMPUTER



**There's a computer in every 1981 GM car and we found this had its pros and cons. But you had better get used to on-board computers—they're here to stay.**

If you buy any of General Motors' 1981 cars, you will also be buying a computer. The Computer Command Control (CCC) exhaust-emission system will both monitor and control many functions in all GM engines.

It's no secret that keeping a car running well and still having it remain nonpolluting, along with getting good gas mileage, can be a mechanic's nightmare. There are many variables involved that must be set and maintained in an engine.

The most important variable is that the mixture of air and fuel be kept to the most efficient ratio for a catalytic converter to operate on. That ratio, by the way, is 14.6 parts of air for each part of fuel.

GM has come up with what might be thought of as an intelligent wrench ready to regulate your engine's functionings at a nanosecond's notice.

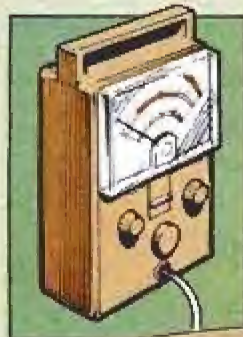
The CCC computer, mounted beneath the dashboard in the passenger compartment, is connected to various

engine components. It monitors and controls carburetor, catalytic converter, oxygen content in the exhaust manifold, coolant sensor in the engine block, and a "check-engine" light in the instrument panel.

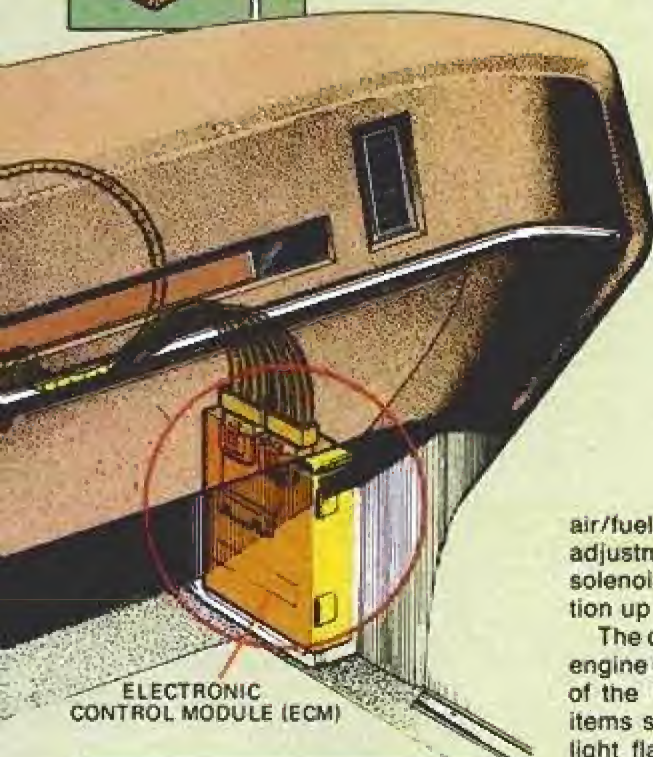
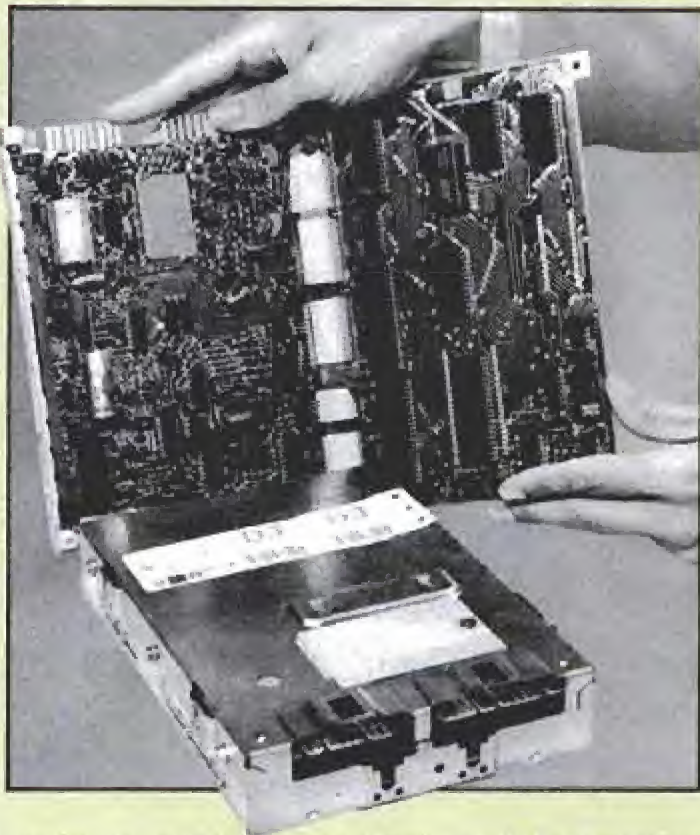
The oxygen sensor in the manifold sends its data to the computer. The computer is also receiving data from the engine-coolant and throttle-position sensors. The computer looks over the information, then uses a solenoid in the carburetor to make the



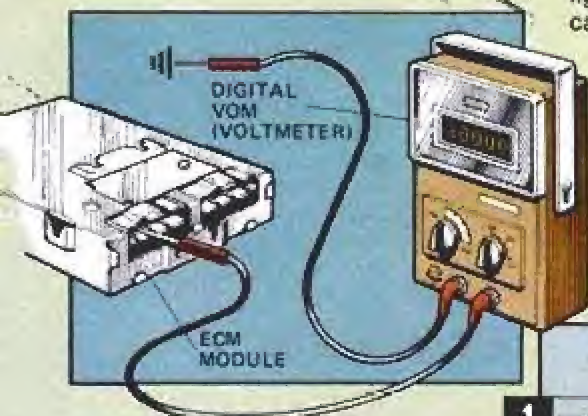
# COMMAND CONTROL



GM's system works by matching input from sensors (circled) with information stored in the computer's memory. The computer (right) is called the electronic control module (ECM) and rides under dash in passenger compartment. A \$200 outlay for digital voltmeter, dwellmeter (left), vacuum pump and various cables lets you service entire system.



ELECTRONIC CONTROL MODULE (ECM)



DIGITAL VOM (VOLTMETER)

ECM MODULE

air/fuel ratio leaner or richer. The adjustment is made by turning the solenoid to a full-on or full-off position up to 10 times a second.

The computer monitors not only the engine components, but also the parts of the CCC system. If any of these items should fail, the "check-engine" light flashes on the dashboard. The car also becomes less responsive—in fact, downright cranky, and impossible to ignore.

At this point, you have a choice: Drive it into a GM authorized-service facility or do the repair yourself. Finding out what is wrong requires about \$200 worth of instruments—a digital voltmeter and vacuum pump, as well

as a few jumper wires and cables.

First thing you would do is ground the test lead coming from the CCC computer. The "check-engine" light would then flash a coded sequence of blinks.

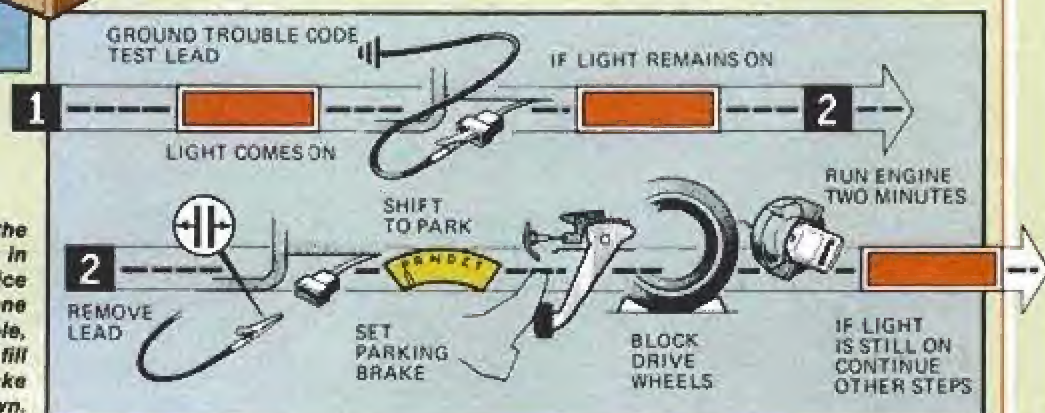
The "check-engine" light, for example, might blink once, then pause and blink three times. It would repeat this over and over (until you disconnected the ground lead) to tell you it was a Code 13 problem. If there are two or more problems, the computer would blink each code in sequence.

Once you have the code, the fun begins.

The service manual leads you step by step in a flow-chart form until you

*(Please turn to page 147)*

We show (right) a part of one of the long, involved flow-chart diagrams in the Computer Command Control service manual. Tests (like the one above, done with a digital voltmeter) are simple, but time-consuming. Most problems fill a few pages in the manual and can take several hours of work to track down.





# May is CAR CARE MONTH


REGULAR CAR CARE IS REWARDING . . . in dollar-savings, energy conservation, safety and in the personal satisfaction of owning a well-maintained, dependable automobile.

















"May is Car Care Month" is designed to bring to the driving public the practical maintenance tips and helpful information on car care products that make car ownership an economical experience, as well as an enjoyable one.

During CAR CARE MONTH the place to go for quality automotive products and money-saving specials is your neighborhood APAA-member Retailer. Many of the products seen in the PM CAR CARE GUIDE will also be featured by Retailers during May.

Check your newspapers for valuable announcements. You will find hints on proper car maintenance and where to buy the products that can help you drive an efficient, safe automobile and save money.

## RETAIL MEMBERS

|   |  |
|---|--|
| <b>ACE<br/>AUTO SHACK</b>   | AZ   |
|  | AK, AL, AR, AZ, CA, CO, CT, FL, GA, HI, IA, ID, IL, IN, KS, KY, LA, MA, MD, MI, MN, MO, MS, MT, NC, NE, NJ, NM, NY, OH, OK, OR, PA, SC, SD, TN, TX, UT, VA, WA, WI, WV, WY |
|  | NC, SC, TN, VA   |
|  | CT, FL, NJ, NY   |
|  | CA   |

|  |                                |   |                                    |
|--|--------------------------------|---|------------------------------------|
|    | NY                             | <b>DART @ HOME</b>  | MO, VA                             |
|    | OH                             |    | IL                                 |
| <b>BALE<br/>TIRE CENTERS</b>   | KY                             |    | IN, OH, KY                         |
|    | CT, MA, RI                     |    | IL, NY, OH, PA                     |
|    | KY, OH                         | <b>Frank's<br/>AUTO SUPPLY</b>  | PA                                 |
|    | MN, WI                         | <b>GRAND/AUTO</b>   | CA, NV                             |
|    | IL, IN                         | <b>Guarantee Auto</b>   | IN                                 |
| <b>BOWDEN'S AUTO<br/>PARTS INC.</b>  | WA                             |   | IN, MD, NC, KY, OH, PA, TN, VA, WV |
| <b>Bowes "Seal Fast"<br/>Co. Ltd.</b>  | Canada                         | <b>Hi-Gear<br/>DISCOUNT AUTO CENTERS</b>  | MD, VA                             |
| <b>Boyer</b>   | MI                             |  | MN                                 |
| <b>cap<br/>CONSUMER AUTO PARTS</b>   | MA                             |  | CT                                 |
|  | IA, MN, MT, ND, NE, SD, WI, WY | <b>INTER-STATE<br/>Automotive Products</b>  | CA                                 |
| <b>Chanslor &amp; Lyon</b>   | CA                             | <b>JACKS<br/>AUTO SUPPLY</b>  | TX                                 |
| <b>CONSUMER<br/>AUTO<br/>PARTS</b>   | ME, NH                         |  | IL, MO                             |
| <b>CRAMP AUTO PARTS</b>  |                                | <b>Joe's Auto<br/>Supply, Inc.</b>  | WA                                 |
|  | NC, SC                         |  | CA                                 |
| <b>Crown/Auto</b>  | MN                             |   |                                    |
| <b>DART @ DRUG</b>   | DC, MD, VA                     |   |                                    |



|   |   |  |  |                                      |   |
|---|---|--|--|--------------------------------------|---|
| <b>KRAGEN</b><br>Auto Supply                            | TX  | <b>NATIONAL</b><br>FAMILY DISCOUNT DEPARTMENT STORES | NJ, NY   | <b>STATEWIDE</b><br>AUTO SUPPLY      | ID, OR  |
| <b>LANGE'S</b><br>AUTO PARTS                            | IL, IN  | <b>Nationwide</b><br>AUTO PARTS                      | FL, GA, IN, KY,<br>OH, VA, WV                                  | <b>Teddy</b><br>AUTO PARTS           | VA  |
| <b>4DC</b><br>AUTO STORES                               | NJ, NY  | <b>OTASCO</b><br>FRIENDLY FOLKS TO SERVE YOU         | AL, AR, FL,<br>GA, KS, KY,<br>LA, MO, MS,<br>OK, SC, TN,<br>TX | <b>The Car Store</b>                 | IL  |
| <b>Leaverton</b><br>Auto Supply<br>Company              | CA  | <b>Parts City</b>                                    | HI   | <b>THRIFTY</b><br>AUTO PARTS         | CA  |
| <b>Majors</b><br>DISCOUNT DEPT. STORES                  | NJ, NY  | <b>Parts World</b><br>DISCOUNT AUTO STORES           | NV   | <b>THRIFTY</b><br>AUTO SUPPLY        | ID, WA  |
| <b>MAJOR</b><br>MOTOR<br>SUPPLY<br>CO.                  | IL  | <b>Penn-Jersey</b><br>AUTO STORES                    | DE, MD, NJ,<br>PA, VA  | <b>TOP AUTO</b>                      | AK, WA  |
| <b>MAPLE</b>  | MA  | <b>Phil's</b><br>AUTO STORES                         | FL   | <b>True Value</b><br>HARDWARE STORES | ALL STATES  |
| <b>MARINO'S HOME</b><br>& AUTO INC.                     | PA  | <b>PHIL'S</b><br>STORES INC.                         | OH   | <b>Twin B</b><br>AUTO STORES         | VA  |
| <b>MID-WEST</b><br>AUTO PARTS<br>COMPANY, INC.          | IA, NE  | <b>PEP BOYS</b>                                      | AZ, CA, DC,<br>DE, MD, NJ,<br>PA, VA                           | <b>U-Save Auto</b><br>Parts Stores   | CA  |
| <b>Modell's</b><br>CHEVROLET WORLD                      | NJ, NY  | <b>Profco</b>  | OH   | <b>Valley's</b><br>Fair              | NJ, NY  |
| <b>WARD</b><br>WHEEL & TIRE                             | AK, AL, AR,<br>AZ, CA, CO,<br>FL, GA, HI, IA,<br>ID, IL, IN, KS,<br>KY, LA, MD,<br>MI, MN, MO,<br>MT, NB, NC,<br>ND, NH, NM,<br>NY, NY, OH,<br>OK, OR, PA,<br>SC, SD, TN,<br>TX, VA, VT,<br>WA, WI, WV,<br>WY | <b>Quality</b><br>Stores, Inc.                       | IN, MI, OH   | <b>VARIETY AUTO</b><br>SUPPLY        | IL  |
| <b>WHEEL &amp; TIRE</b>                                 | VA  | <b>R&amp;S</b><br>AUTO PARTS                         | NJ, NY   | <b>Wells auto</b><br>supply inc.     | MN  |
| <b>WHEEL &amp; TIRE</b>                                 | GA  | <b>Renninger's</b>                                   | PA   | <b>WESTERN AUTO</b>                  | ALL STATES<br>EXCEPT SD   |
| <b>NATIONAL</b><br>AUTO SUPPLY<br>PARTS AND ACCESSORIES | MA, NY  | <b>ROSE</b><br>AUTO STORES                           | FL   | <b>WHITLOCK</b><br>AUTO SUPPLY       | IA, IL, KS, OK,<br>WI   |
|   |   | <b>STAR</b><br>AUTO PARTS                            | NJ   | <b>WOW</b>                           | NV  |
|   |   | <b>Strauss Stores</b>                                | NJ, NY   | <b>Zayre</b>                         | AL, CT, FL, GA,<br>IA, IL, IN, KY,<br>MA, MD, ME,<br>MI, MN, MS,<br>MO, NC, NH,<br>NJ, NY, OH,<br>PA, RI, TN, VA,<br>VT, WI |

# CarCare Central



## The TV Show to Help You!

APAA has joined with top professionals in both the automotive and entertainment world to produce CAR CARE CENTRAL.

- A new, 26-week Television Series.
- Dedicated to helping people take better care of their cars through better maintenance.
- Aired in prime time weekend hours.
- To begin during April and May.

In addition to demonstrations of auto maintenance procedures, CAR CARE CENTRAL will feature interviews with top celebrities and experts in the automotive field.

Check your local newspaper for times in your area. Participating Retailers will have details and also offer POPULAR MECHANICS-prepared brochures illustrating the subjects covered in each TV show. Watch CAR CARE CENTRAL. It's designed for car owners who want their cars to run better and last longer.

**APAA**  
AUTOMOTIVE  
PARTS & ACCESSORIES  
ASSOCIATION

**Popular Mechanics**



# THE COMPUTERIZED

GM's Computer Command Control is just the beginning.

Even more advanced computers will soon turn the family car into a dream machine.

**"A**nd where would you like to go today? Run program or manual boss?" the sultry, alluring voice purred.

The driver settled himself into a seat which instantly moved to his favorite driving position. His hands gripped the wheel and he answered, "Let's head for Chicago, Helen. Route-program Four-Delta and keep your locator on. Keep all visuals on priority standby and, please, don't let me miss the information dump from the Buffalo office."

"Anything you say, boss." The disembodied voice's tone was assured and competent as the car rolled smoothly into the traffic flow.





# CAR OF TOMORROW

## Stranger than fiction

The scenario above isn't an outtake from *Buck Rogers*, but a pretty good prediction of how a daily drive will begin in the quite-near future. Now that computers have arrived in today's cars, tomorrow is closer than ever before. All it will take is the next generation of automotive computer.

In case you haven't guessed, the disembodied voice was our car's voice output. The driver spoke his words into a microphone built into the wheel—and the car followed his orders. If this leaves you skeptical, bear in mind that voice input and output is already being used—in everything from televisions

that follow spoken requests for channel changes to clocks that speak the time out loud.

In fact, everything we have included in our car of the future can be done now with computer technology. Let's take a look at just a few of the systems such a car will feature.

## Map/locator

You're never going to get lost driving this car. The computer stores (via bubble memory) maps of the 300 largest American cities. Under the hood is a sophisticated locating system based on today's loran C radio navigational aids. This loran C unit feeds its





**WHEN YOU'VE GOTTA RELY ON YOUR CAR, RELY ON HARDWORKIN' AC-DELCO PARTS.**

AC-Delco. They're the hot-firin', cold-crankin', road-handlin', dirt-fightin', hardworkin' replacement parts for your car.

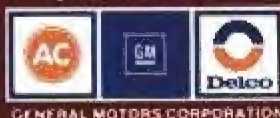
For more than 50 years, hardworkin' people have relied on AC-Delco parts. In their cars.

Trucks. Boats. Motorcycles. It's the one name they look to for just about everything — for just about anything that moves.

There's maintenance-free Delco Freedom II Batteries for powerful starts. Big Delco Shocks. Tough AC Filters to help trap dirt. And AC Fire Ring

Spark Plugs. They heat fast. Fire hot. And help resist foul-ing. If your car's plugs are mis-firing, a tune-up with a new set of AC Spark Plugs can help improve gas mileage.

When your car's got work to do, go with the brand that's built its reputation on hardworkin' reliability: AC-Delco.



# AC-DELCO HARDWORKIN'





## CAR OF TOMORROW

(Continued from page 145)

data directly to the car's main computer.

What you see as you're driving is a map like a Trip-Tik. A moving spot on the map represents the position of your vehicle—accurate to about 20 feet.

### On the big screen

Videodiscs right now can store up to 54,000 video frames on an LP-size digital platter.

The first experiments have recently taken place on interfacing computers to videodiscs. One university lab features a large projection TV hooked up to a videodisc. The disc, in turn, is controlled by a computer. The operator sits in a chair and, using hand controls, takes a "walk" through a videomapped city. The effect is very much like being in the real city.

Our car features such a system, but hooked in right to the steering wheel. If you're heading for a strange city, you will first buy yourself a videodisc tour, plug it into your car and then "drive" through that city without leaving your garage. And, if you're heading through a scenic area at night, just pop in the videodisc for that area. Your passengers will be able to enjoy the show—but keep your own eyes on the road.

One thing about using an advanced computer—you will have such a wealth of detail that you couldn't possibly view it all at once. The dashboard would be lit up like a minor explosion. Most of the dash displays will be multipurpose.

Some controls will be the familiar ones of today—everything from courtesy-light switches to a cigaret lighter (for the future's noncarcinogenic smokes). We show these controls on a rotatable, mushroom-shaped Lazy Susan. Other controls, grouped on the steering wheel, let you quickly call up various instrumentations. One display, a small monitor, will become the focal point of your observation. Shown will be a three-dimensional "ghost" image of your car, with any offending part or system flashing red.

The main video display will be used not only for videodisc viewing but, in an emergency or service situation, the entire status of the car—a system-by-system check—can be "dumped" to the screen.

True collision avoidance may or may not ever become reality. But there's no doubt that the computer will be used to alert the driver to emergency conditions.

The on-board computer will be in constant communication with highway patrol computers, which will keep it advised of road conditions, speed limits, accidents and the like.

The car of tomorrow is closer than you think. Computers have already opened the door.

PM

## GM'S COMPUTER COMMAND CONTROL (Continued from page 141)

The electronic control Module (ECM), or computer, slides out of its carrier under the dash in the passenger compartment. But, for most service, there is no need to remove the computer. If anything does go wrong with the computer, GM dealers will offer rebuilds under \$200.



locate the actual component causing the problem. Some of the flow charts are straightforward. But some go on for many pages and can take hours.

The dealer cost of a new computer is \$250. That would likely work out to around \$350 retail.

But, even if your computer does die, you won't be socked with such a heavy expense. GM has set up a number of remanufacturing plants. A rebuilt computer will cost between \$100 and \$200. The question is: Is the cost—both original and replacement—worth it?

It depends. It would seem that a CCC system on a small Four simply adds an unnecessary layer of complexity. None of the Japanese cars on the market has a system anywhere near as complex to keep engines clean and efficient. Their four-bangers accomplish good mileage with conventional electromechanical controls.

For surviving V8s, the CCC is probably the only way to achieve adequate mileage and emissions levels.

One matter of critical importance to the Saturday mechanic is servicing the system. While troubleshooting and diagnosis procedure is not difficult, it is certainly time-consuming. With labor rates for professional mechanics ranging from \$18 to \$36 per hour, the cost of tracing a problem might be three or four times the price of the faulty part.

Local garage operators, who as a rule don't keep up with the latest technical manuals, will probably be even less familiar with this system than a dealer's service department.

Ultimately, the owner of a GM car will be forced, by financial necessity and an information gap, into learning as much as he can about the CCC to keep his car in shape. The information is certainly available and inexpensive. And, in the long run, the owner might be best off doing the job himself.

Our PM Owners Reports on GM's '81 cars will be examining the reaction to this Computer Command Control.

### Now and tomorrow

Technically speaking, the computer is a 6809 CPU running at 1 MHz, and addressing 8K of RAM and 250 words of RAM memory. Putting that in English boils down to a computer somewhere around the sophistication of a good home computer, but under-utilized.

A 6809 CPU (the "brain" of this computer) can access a program of 48K, or six times the amount of program now there. All it needs is the additional memory—and that is very inexpensive. Programs, which tell the computer what to do and when to do it, are stored in plug-in "chips." The only difference between the computer in a Caddy and one in a Vette is the different program.

Programs right now are set to give high fuel economy. But, as we mentioned in *PM Electronics Monitor* (page 32, March '81), there is no reason why an aftermarket should not develop in these program chips. If you want to lose a few miles per gallon and gain quicker acceleration, it may someday mean just changing a program chip.

There are many—at least a dozen—totally unused "ports" on the present configuration of the GM computer. These ports are ready to accept information from anywhere you might install a sensor—and they are also ready to control other devices.

Any good electronics technician, working with an accomplished computer programmer, should be able to think of numerous add-ons to the present computer system. Everything from instant and continuing mileage reports to collision avoidance might be right on the automotive horizon.

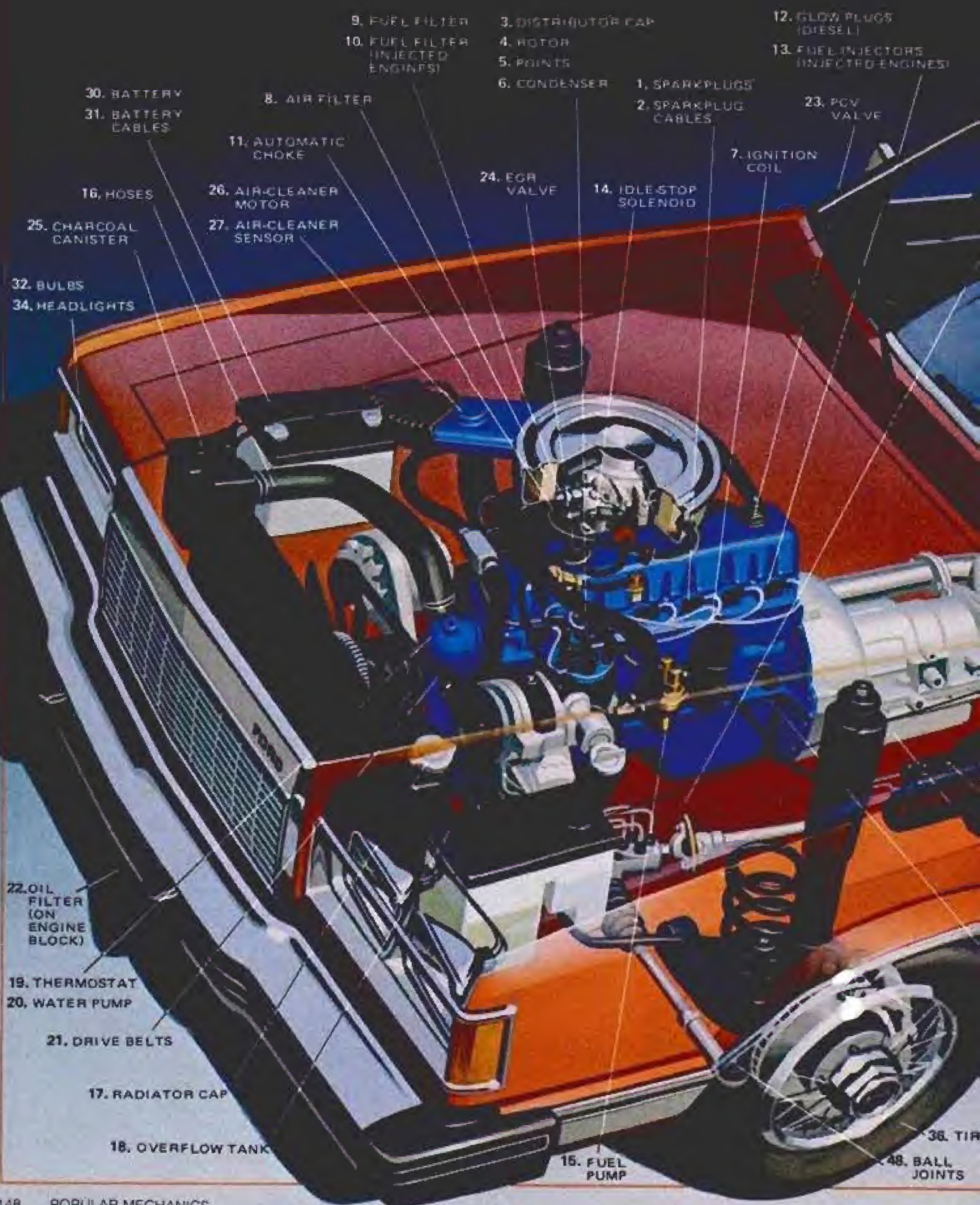
Our accompanying story, *The Computerized Car of Tomorrow*, details how the computer revolution in automobiles may culminate in a Buck Rogers dream world.

GM deserves credit for being the first to put computers in all its cars. In one way or another, the computer will never leave.

PM



# THE 50 MOST COMMONLY

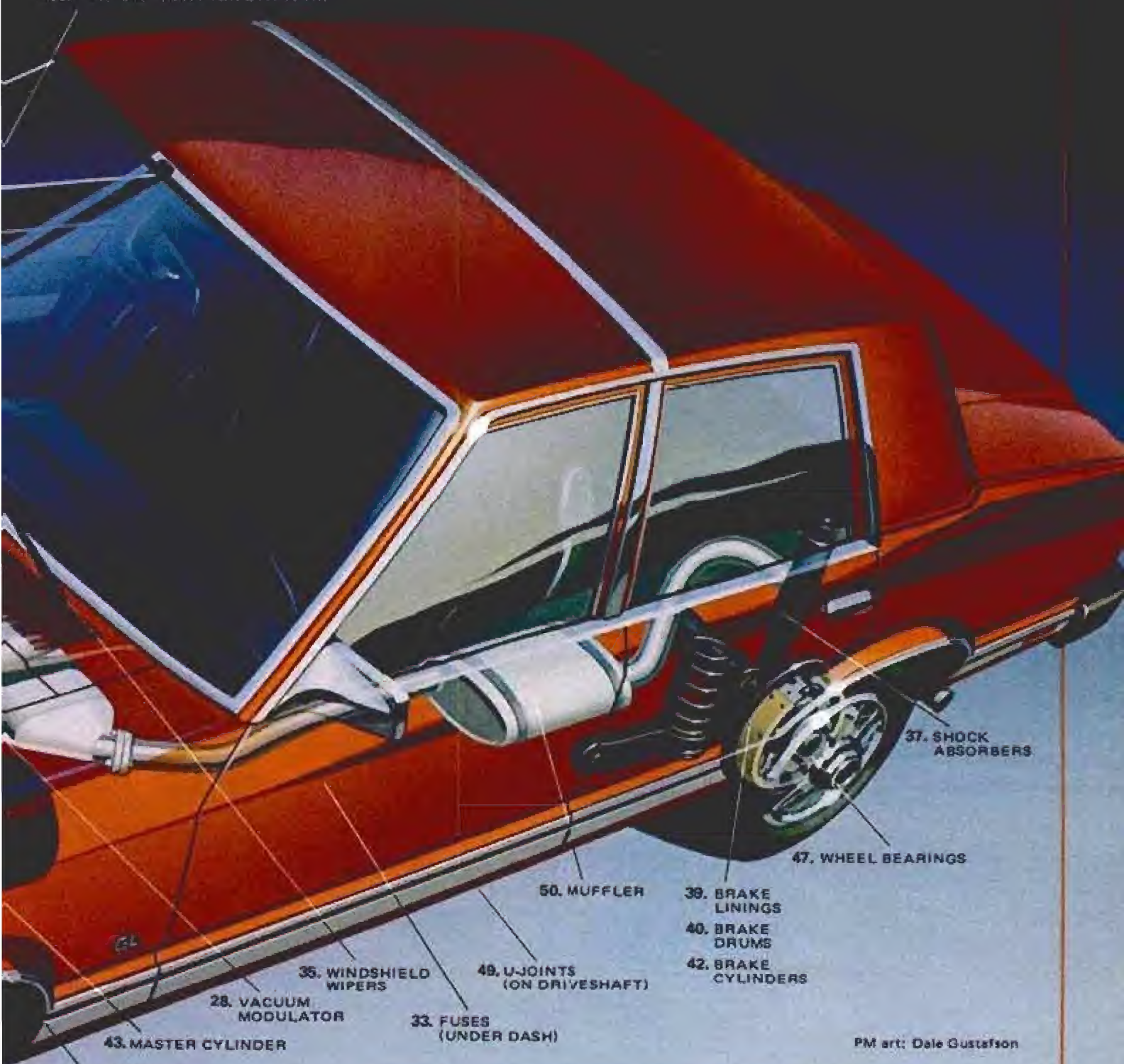




# REPLACED PARTS OF YOUR CAR

44. STARTER MOTOR (ON ENGINE BLOCK)

45. STARTER RELAY (ON STARTER)



28. VACUUM MODULATOR

29. TRANSMISSION-FLUID FILTER

38. BRAKE PADS

41. BRAKE ROTORS

33. FUSES (UNDER DASH)

50. MUFFLER

48. U-JOINTS (ON DRIVESHAFT)

35. WINDSHIELD WIPERS

28. VACUUM MODULATOR

43. MASTER CYLINDER

39. BRAKE LININGS

40. BRAKE DRUMS

42. BRAKE CYLINDERS

47. WHEEL BEARINGS

37. SHOCK ABSORBERS

PM art: Dale Gustafson

**Regular maintenance or replacement of these critical parts will keep your car running—and your mind at rest—for years to come. The following 50 sections will tell you how to spot malfunctions in each of these parts, and how to fix or replace them.**



# ONLY FORD DOES IT! 21 MPG\* WITH 2,530-LB. PAYLOAD.



Ford, America's best-selling pickup for four straight years, leads again in '81. It's the first and only pickup that can deliver 21 estimated MPG and over 2,500 lbs. of payload. And Ford's husky 300 Six also delivers more engine torque than competitive Sixes. Why settle for less? Pick a pickup designed for the needs of the 80's—the tough, efficient '81 Ford.

**29**

EST.  
HWY.\*

**21**

EPA  
EST.  
MPG\*

F-100/150 with 4.9L (300 CID) Six

**First Ford 21 MPG Six\***

Only the tough '81 Ford has an estimated MPG this high with payloads as big as 2,530 lbs.

\*With 4-speed overdrive option. Compare these estimates with others. Your mileage and range may differ depending on speed, distance and weather. Actual highway mileage, range and California ratings less. Ford's mileage ratings together with the largest fuel tank of any pickup give the longest range.

**1102**

HWY.  
MILES\*

**798**

EST.  
MILES\*

LWB Styleside with optional tank

**First in driving range\***

Only Ford has this estimated range. Standard and optional 19-gal. tanks total 38 gallons.

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# 1. SPARKPLUGS

**S**parkplugs that don't function properly cause one or more of the following engine problems:

- Hard starting.
- Stalling.
- Rough idling and roughness when driving at lower speeds.
- Misfiring at higher speeds.
- Lack of power upon acceleration.
- Excessive fuel consumption.

Other components of a gasoline engine can cause one or more of the same conditions. To determine whether sparkplugs are at fault, therefore, remove them from the engine for examination.

## Removing sparkplugs

**1. Write numbers on strips of masking tape for use in labeling sparkplug cables.**

If the engine is a four- or six-cylinder in-line model mounted longitudinally, number cables consecutively from the front of the engine toward the rear.

If the engine is a four-cylinder transverse-mounted model, number cables consecutively from left to right as you face the engine compartment from the front.

If the engine is a six-cylinder transverse-mounted model, number the grille-side cables F-1, F-2 and F-3 as you face the engine compartment from the front ("F" stands for front). Number the firewall-side cables R-1, R-2 and R-3 as you face the engine compartment from the front ("R" stands for rear).

If the engine is a V8, number the left bank cables L-1, L-2, L-3 and L-4 from the front toward the rear as you face the front of the engine. Number the right bank cables R-1, R-2, R-3 and R-4 from the front toward the rear as you face the front of the engine.

**Caution:** Proper identification of sparkplug cables is important to avoid incorrect reinstallation that would throw engine firing out of line, possibly causing engine damage.

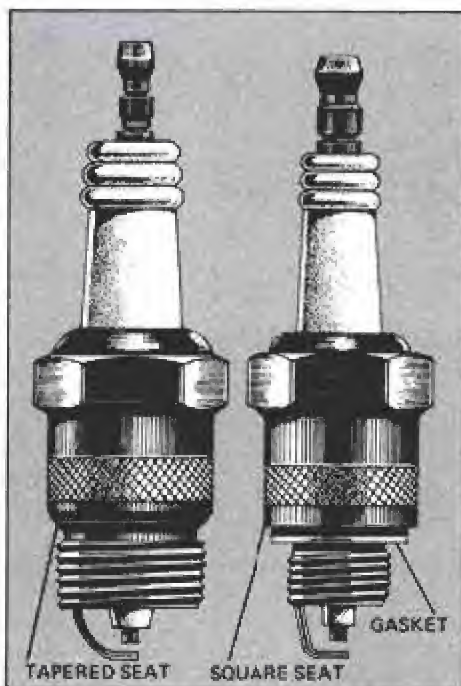
**2. Use a sparkplug cable-removing tool (your auto parts and accessories dealer can recommend one) to grasp boots over sparkplugs.** Twist and pull until boots pop off.

Sparkplug boots in some cars (K-cars, X-body models and Escort/Lynx, for example) don't require use of a sparkplug cable puller. Boots are extra thick and large, forming handles that permit you to easily grasp and pull them loose by hand.

**Caution:** Don't pull on sparkplug cables themselves. You will tear apart electrical conductors inside the insulation, ruining the cable. Pull only on boots.

**3. Clean out sparkplug ports to prevent dirt particles from falling into cylinders as plugs are removed.** Particles in cylinders may cause engine damage.

If you have an air compressor, direct bursts of compressed air at the ports. If you don't have a compressor, a product called Dust-Off, which is available in photo stores and hobby shops, is good to use.



*Installation methods vary if plugs have gaskets or if their seats are tapered.*

**4. Using a ratchet wrench and correct-size socket, turn plugs counter-clockwise to loosen and remove them.** A 3/4-in. hex socket fits most sparkplugs, but a 5/8- or 7/8-in. size may be needed.

As you remove each plug, wrap a piece of masking tape around it and write a number on the tape that coincides with the cylinder number from which the plug was taken. If plugs are to be reused, put each back where you took it from.

## Reinstalling sparkplugs

Whether you reuse sparkplugs or install new ones, be sure they are gapped to the specification recommended in manufacturer service literature or on the vehicle emissions-control label in the engine compartment. Use a wire sparkplug feeler gauge—not a flat-blade type that will result in an erroneous adjustment.

Push and pull the gauge in and out between electrodes. The gap is correct when there is a slight drag (friction) on the gauge.

Put plugs in the engine as follows:

**1. Install new plugs having the same designation, unless plugs that have been used in the engine show they were intended for a different heat range.**

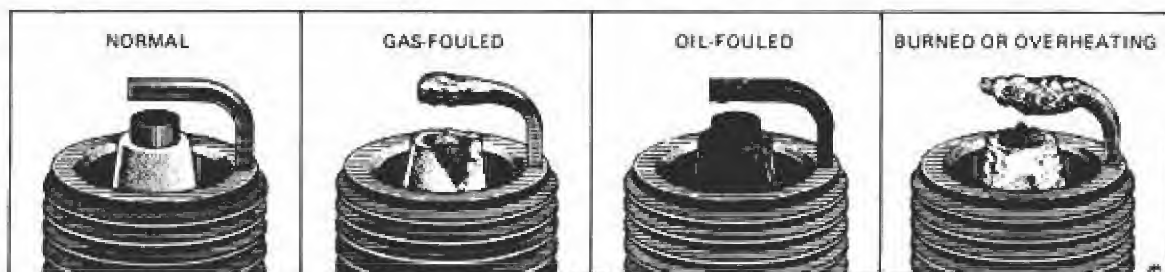
**2. Examine the threaded ends of plugs to determine whether they have square seats that use gaskets, or have, instead, tapered seats that seal themselves to the cylinder head without the need for gaskets.** This information will help you establish to what degree plugs should be tightened.

**3. Use a sparkplug thread chaser to clean sparkplug port threads before installing the plugs.** This tool is screwed into ports to clean particles from threads. Particles can lodge between a sparkplug and cylinder head, causing compression loss and possibly ruining sparkplug or cylinder head.

**4. Screw plugs into the cylinder head until they are finger-tight.** If plugs have tapered seats, tighten them 1/8 of a turn from the finger-tight position. If plugs use gaskets, tighten them 1/4 turn from that position.

**5. Reconnect sparkplug cables to their respective sparkplugs.** **FM**

**Sparkplug condition can be used as a diagnostic tool to check an engine's condition. Severely damaged plugs with broken insulators and eroded electrodes should be replaced. Sparkplugs cannot be repaired.**

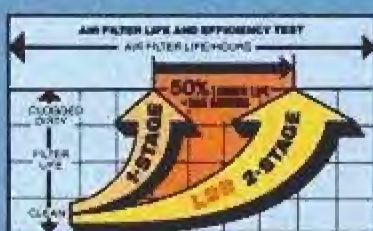




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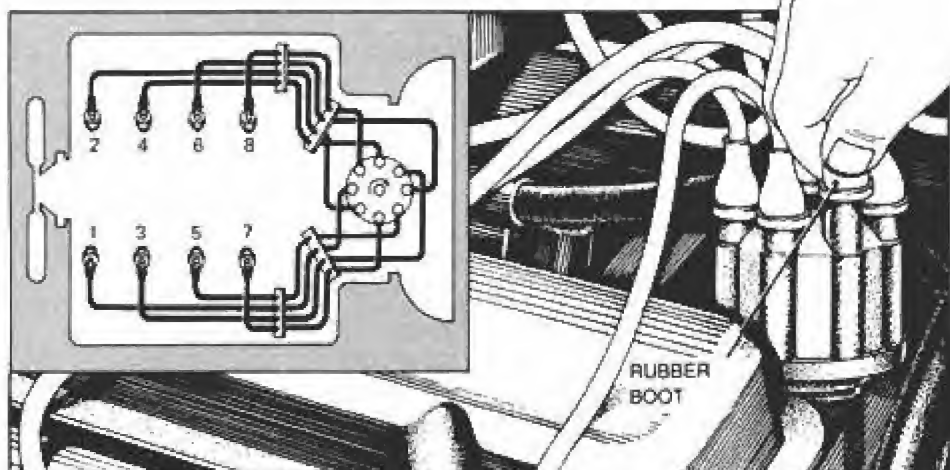
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## 2. SPARKPLUG CABLES



When removing sparkplug cables, always grasp the boot, twist and pull out. Don't pull on the wire alone. To identify cables to the proper plugs, use tape with numbers.

Faulty sparkplug cables bring about the following engine problems:

- Hard starting or failure to start.
- Stalling.
- Rough idling or roughness, when driving at lower speeds.

When one of these conditions occurs, wipe the cables with a rag and inspect them. Bend each cable back and forth as you look for cuts and cracks. Replace cables that are damaged.

Even if cables don't show damage, they may have invisible breaks. To test for them, attach one end of a jumper wire, whose ends are outfitted with alligator clips, to the shank of a screwdriver. Attach the other alligator clip to a clean ground on the engine.

Start the engine and disconnect one sparkplug cable at the sparkplug. See that the boot of the cable faces away from metal and pass the tip of the screwdriver slowly along the length of the cable. Keep the screwdriver  $\frac{1}{16}$  to  $\frac{1}{8}$  in. from the cable.

If a spark jumps from the cable to the screwdriver, there is a break in the cable. Replace it. After a cable has been tested, reconnect it securely to its sparkplug and test the next cable.

To test the ignition coil-to-distributor-cap cable, which has to remain attached on both ends for the engine to run, leave one of the other cables disconnected. Pass the screwdriver along the length of the ignition coil-to-distributor cable. There will be enough resistance in the circuit to cause a spark if there is a break in the cable.

### Replacing sparkplug cables

Remove faulty cables from sparkplugs and the distributor cap. Be sure to buy the correct type of cables. Cables you buy should be as long as cables you are replacing.

Note: Replace only those cables that fail to

pass inspection. You don't have to replace cables as a set.

Generally, cables for use in today's cars are called TVRS cables. TVRS stands for Television-Radio Suppressor. This type of cable prevents auto ignition systems from interfering with TV and radio reception. If you need assistance in selecting cable for your car, ask your auto parts and accessories dealer.

To attach cables to sparkplugs, grasp the boots. Push and twist them onto the plugs until they won't go any further.

To install a cable into a distributor-cap tower or a coil, grasp the boot. As you push and twist the cable into the tower, squeeze the boot to expel air.

Caution: Crossfire is a condition that allows current flowing through a cable to be induced into an adjacent cable, causing a sparkplug to fire out of turn. The result could be damage to engine parts.

To prevent crossfire, know the positions of sparkplug cables in their relation to each other. See that two cables of consecutively firing sparkplugs are not parallel to each other, especially at their lower lengths. To avoid crossfire, these cables should cross.

### Silicone wire

The best way to ensure reliable life from your sparkplug cables is to use silicone wires. Most older cars came equipped with organic, rubber-jacketed cables which deteriorate rapidly. Silicone-jacketed cables resist deterioration caused by ozone, your cables' No. 1 enemy, and heat. Currently, the industry tests silicone cables at 500°F. without failures. Tests have also shown that silicone withstands higher voltages and is impervious to deterioration.

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# 3. DISTRIBUTOR CAP 4. ROTOR

**D**espite the advent of electronic ignition systems during the 1970s, there are still millions of cars equipped with conventional distributor ignition systems. Unlike electronic ignition, conventional ignition has parts that are subject to wear and damage. These include the distributor cap, rotor, breaker points and condenser.

A damaged distributor cap, rotor, breaker points or condenser will be responsible for some or all of the following engine problems:

- Failure to start or hard starting.
- Stalling.
- Rough idling or roughness when driving at lower speeds.
- Misfire at higher speeds.
- Lack of power upon acceleration.

Where damage exists, it will become apparent when parts are inspected. Each part, therefore, should be removed from the distributor and examined carefully.

## Replacing a distributor cap

**Note:** This information applies, as well, to distributor caps of electronic ignition systems, which should be inspected if one of the conditions listed above occurs.

**1. Use numbered pieces of masking tape to identify each cable and its respective distributor-cap tower.** Attach the same number to both as you remove each cable from the cap.

Cables must be returned to their correct positions in the distributor cap to avoid engine failure and possible damage that is caused by out-of-timing ignition.

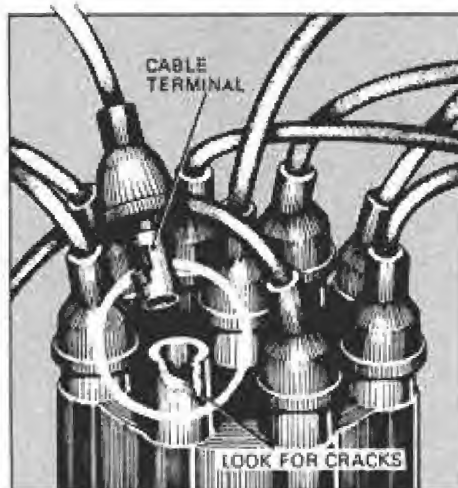
**2. Inspect the distributor-cap tower for broken plastic, cracks and chips.** As you remove each cable, inspect the terminal for burned metal, which is an indication that arcing has occurred somewhere between the cable terminal and distributor-tower terminal.

If signs of burning are present, replace the distributor cap and also the cable, which is probably damaged.

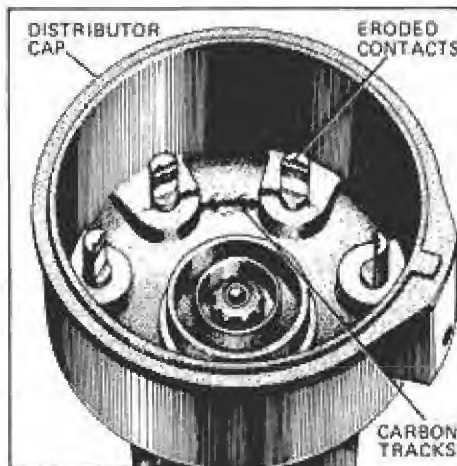
**3. Unhook the distributor cap from the distributor after the cables are removed.** A cap will generally be secured to the distributor in one of the following three ways:

■ By spring clips, one on each side of the cap. Insert the blade of a screwdriver between clips and the distributor body and twist the blade to snap the clips free. Be very careful not to apply any pressure against the plastic cap. You run the risk of cracking the plastic.

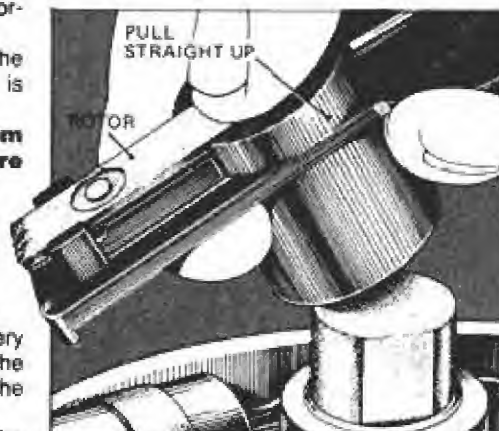
■ By L-hooks, one placed on each side of the cap. These have slotted heads. Insert a screwdriver into the heads and rotate the hooks



Check distributor-cap towers for cracks. Examine terminals for corrosion or rust.



Check contacts for burned or eroded metal and examine the cap for carbon tracks.



Rotor should come off with gentle force. Examine rotor tip for corrosion, arcing.

counterclockwise one-half turn in order to free the cap.

■ By screws, one located on each side of the cap. Turn these screws counterclockwise until the cap is free.

With the cap removed from the car, wipe it outside and inside with a clean cloth to remove all dirt and grease. Using a flashlight, examine the cap inside and out, including the inside towers.

Look for visible cracks; tracks of carbon which reveal narrow, hard-to-see cracks; pitted, burned or eroded contacts inside the towers and on the inside (back) of the cap; and chipped plastic. Replace the cap if any damage is discovered, no matter how insignificant it may appear.

If the cap is okay, reuse it, but first clean the inside of each tower using a distributor-cap cleaning tool. Reinstall the old cap, tighten the hold-downs and make sure that each numbered cable fits into its respectively numbered cap tower.

If you should have to install a new cap, line up the old and new caps so that their distinguishing marks coincide. Then, transfer the numbered masking tape from the tower of the old cap to the respective tower of the new cap.

When installing the distributor cap, make sure it is oriented correctly and sitting properly on the distributor. If dirt gets into the distributor, it will cause premature failure of points and rotor.

## Replacing a distributor rotor

**Note:** This information applies to the rotors of conventional and most electronic ignition systems.

**1. Remove the distributor cap.**

**2. Remove the rotor, which is mounted on top of the distributor shaft.** Generally, there are two kinds of rotors:

■ Press-fit rotor. Remove this type by grasping and pulling it straight off the distributor shaft.

■ Screw-on rotor. Remove this rotor by unfastening the screws that hold it in the distributor. Then you can lift the rotor off the shaft.

**3. Replace the rotor if the plastic body is cracked, chipped or shows carbon tracks, or if the spring contact is corroded, burned or exhibits weak tension.**

**Important:** Be sure to buy the correct rotor for your engine. A press-fit rotor will fit a variety of distributors, although the rotor may not be the correct part. Line up the new rotor and the old one and check to see that they are exactly the same size and shape.



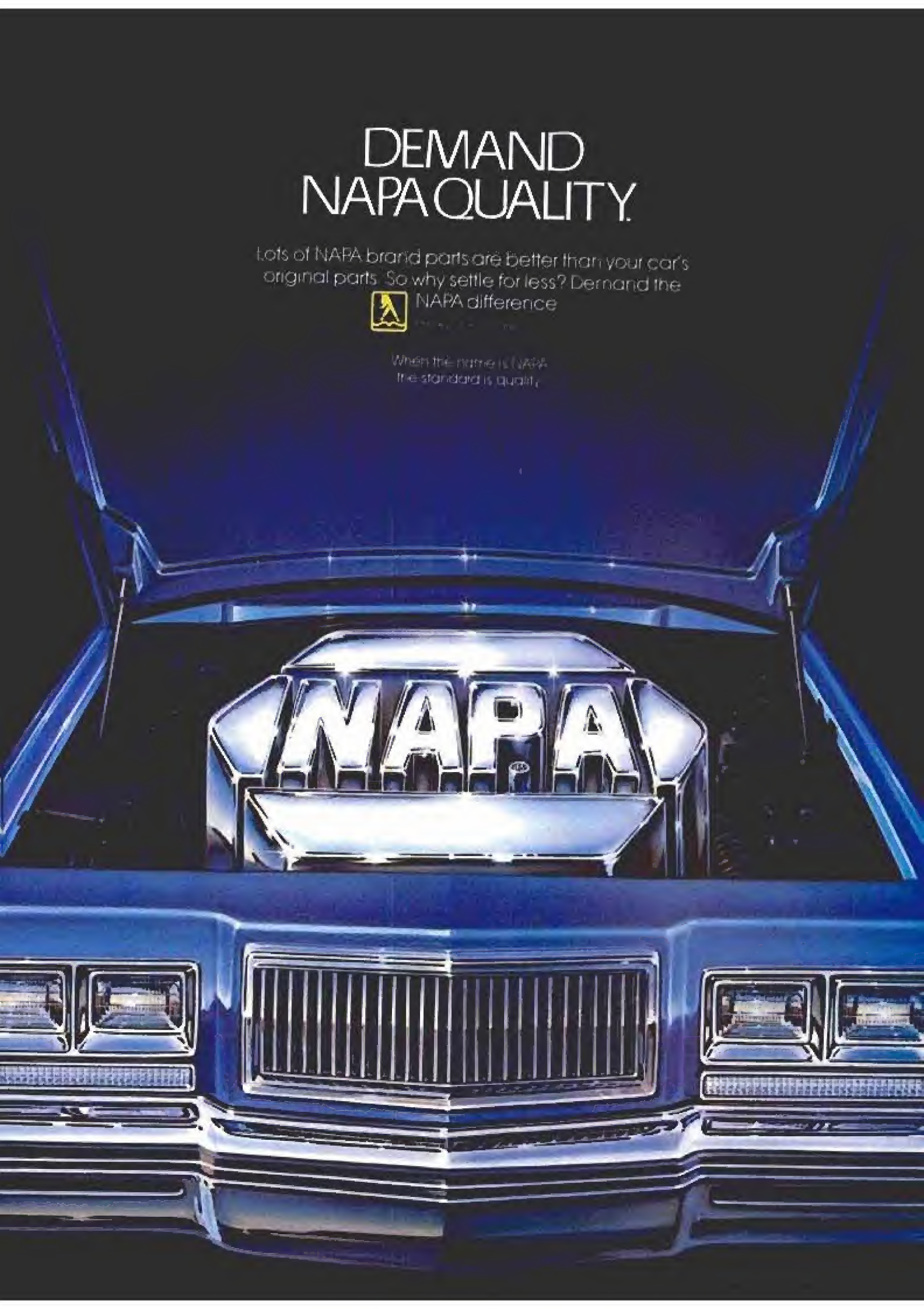
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## 5. POINTS 6. CONDENSER

**M**alfunctioning distributor points will make your car run rough, miss, diminish performance, waste fuel and, ultimately, when the component fails, prevent your car from running at all.

To avoid being left in the lurch by failed points, inspect them regularly. Here's how:

**1. Remove the distributor cap and rotor.**

**2. Spread points apart for a better view.** If you cannot see them clearly, remove them for inspection.

Point surfaces should not be pitted; that is, no buildup of metal on one point and no cavity, or cavities, on the other.

Pitted points mean the condenser is defective, a reason for replacing points and condenser. If points are black, corroded or worn, replace them. *Note:* A slight bluish cast on point surfaces is normal.

**3. Remove points from the distributor.** Loosen the small nut on the side of the point assembly to free the condenser primary ignition wires and lift out the point assembly.

*Note:* As you remove parts, lay them out in the order you take them off. Reinstall them in reverse order. If you are doing this job for the first time, make a sketch as you proceed. It will help to reassemble a unit correctly.

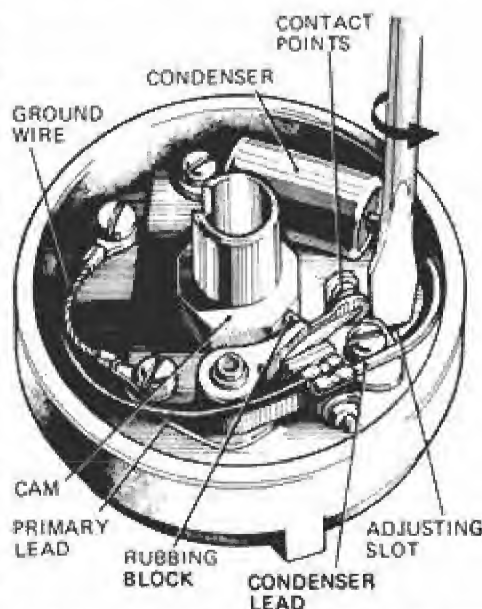
**4. Examine the point assembly to determine location of the mounting screw, or screws.** Remove screws, but be careful they don't drop in the distributor.

**5. In some cases, the condenser is part of the point assembly.** You can't replace one without the other. In other cases, condenser and points are separate. To replace the condenser, remove the screw holding it in the distributor and lift out the part.

**6. To install points in a distributor not in a General Motors car, use the following procedure:**

- Keep point-assembly screws finger-tight. Attach primary ignition condenser wires.
- Make a chalkmark from the distributor housing onto the engine.
- Loosen the distributor housing with a distributor wrench and rotate it until the point-assembly rubbing block rests on a high point of the distributor cam. The block is the point-assembly part against which the distributor cam moves to open and close points.
- Determine from manufacturer service literature or the vehicle emissions-control decal the point adjustment specification. Twist a screwdriver tip in the point assembly cutout slot to open the points.
- Open points enough to slide the correct-size feeler gauge between them. Then adjust point spacing until a slight drag is felt as you move the gauge blade between the points. Try to insert the next larger size blade between the points, without forcing it. If it won't fit, points are adjusted properly. Tighten the point assembly hold-down screws.

*Caution:* Before inserting a feeler gauge



*The point gap is set by inserting a screwdriver into the adjusting slot and twisting it until the size of the gap is correct.*

between points, wipe the blade clean. Dirt transferred from blade to point surfaces causes premature point failure.

■ Turn the distributor so the chalkmarks are lined up and tighten the distributor-housing mounting bolt.

■ If the distributor cam has a lubricating pad, replace the pad. If the cam does not have this pad, place a tiny drop of distributor-cam grease on a high point of the cam. If a pad is centered in the distributor shaft, apply two drops of light oil.

*Caution:* Overlubricating this cam will cause point failure if lubricant splashes onto point surfaces. Use a minimal amount of lubricant.


■ Install the rotor and distributor cap. Then, using a dwell/tachometer, adjust point-dwell angle to engine manufacturer specification. Follow instructions provided by the instrument manufacturer.

**7. If you have a General Motors distributor, do the following to complete the job, once distributor points and condenser have been installed:**

- Tighten distributor-point assembly screws.
- Lubricate the distributor cam (see above) and install rotor and distributor cap.
- Connect a dwell/tachometer. Start the engine and open the small window on the side of the distributor cap.
- Insert an Allen wrench in opening in the point assembly and adjust point dwell to specification by turning the wrench.
- When dwell is to specification, be sure to close the distributor cap window tightly. Leaving it open just a crack allows dirt and grease to enter the distributor. Turn off the engine and remove the dwell/tachometer.

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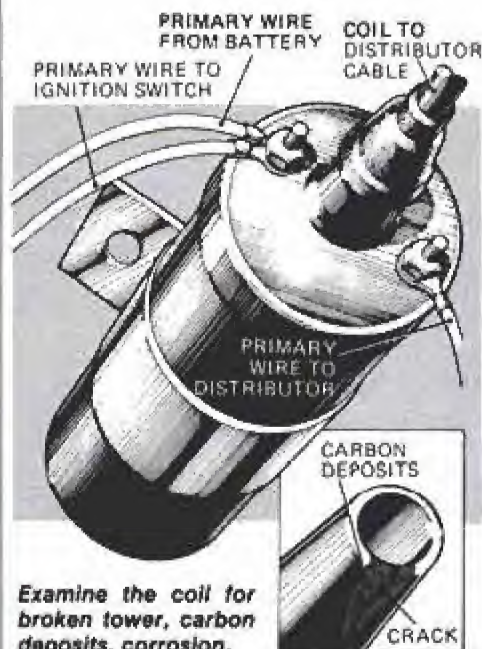
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## 7. IGNITION COIL



Examine the coil for  
broken tower, carbon  
deposits, corrosion.

**A** bad ignition coil, in a conventional or electronic ignition system, causes:

- Hard starting or failure to start.
- Stalling.
- Rough idling or roughness when driving at lower speeds.
- Misfiring at higher speeds.
- Lack of power on acceleration.
- Backfiring.

If you experience any of these problems, inspect the coil for cracks in the coil body. Disconnect the high-tension cable from the coil tower by turning and pulling the boot. Inspect the outside of the tower for broken areas, cracks and chips. Look inside the tower at the coil contact and also inside the cable boot at the cable terminal. If these areas are burned, arcing has taken place because of a loose connection between the terminal and contact. Replace the coil and cable.

To test the internal integrity of an ignition coil, you need an ignition coil tester. If you suspect that the coil is causing trouble and you can't tell, have it tested by a mechanic.

To replace an ignition coil:

1. **Disconnect the primary ignition wire from the coil negative terminal.** Using masking tape, mark this wire NEG.
2. **Disconnect the wire attached to the coil positive terminal.** This wire goes from the coil to the ignition switch. Mark this wire POS.
3. **Disconnect the high-tension cable from the coil tower.**
4. **Remove the coil by loosening the bracket holding it to the engine.**
5. **Install a new coil.** Make sure wires are connected tightly to correct terminals. **FM**



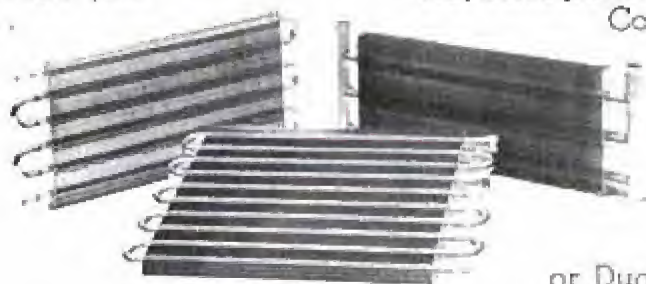
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WD-40 COMPANY, San Diego, CA 92110

## 1981 CAR CARE GUIDE

# 8. AIR FILTER



**An air filter cannot be serviced. If it's defective, you must replace it. Examine the filter with a drop light and look for any tears or holes in the filter element.**

**A**n engine exhibits the following symptoms when the carburetor air filter gets clogged (a clogged air filter restricts the flow of air to the engine):

- Hard starting.
- Stalling.
- Rough idling and roughness when driving at lower speeds.
- Misfire at higher speeds.
- Pinging.
- Black or gray exhaust smoke.
- Lack of power.
- Excessive fuel consumption.

To determine whether the air filter is responsible for any of these conditions, remove it from the air-cleaner housing and give it a thorough inspection.

### Replacing the air filter

If your engine has a circular or oval air-filter housing, remove the wingnut in the center of the cover and open the clips, if any, around the edge of the cover. Lift up the cover and remove the filter.

If your engine has a rectangular air-filter housing, release the clips and/or wingnuts holding the front part of the air cleaner. Pull the cover off the air cleaner, so you can remove the filter.

Check the filter as follows:

1. **Tap the filter lightly on a hard surface to free loose dirt.**
2. **Hold a drop light in the center of the filter and look through the element.** If the filter is clogged so light doesn't shine through it, or if it is torn or covered with oil, replace it.
3. **If the filter is rectangular, hold it to a bright light and check for the conditions described above.**

**Note:** It's a waste of time trying to clean an air filter by washing it or blowing on it with compressed air. This will only destroy the filter.

**4. Wipe the air-cleaner housing before you reinstall the original air filter or you install a replacement air filter.**

**Caution:** Many filters have the word UP printed on one side. Install the filter with this side facing up or, in the case of a filter mounted transversely, facing toward the front of the car. This is especially important when installing a filter that has been in use. If a used filter's position has been reversed, the dirt that has accumulated on the filter may be drawn into the engine.

**5. Replace the filter cover and hold-downs.** Do not overtighten wingnut and bolt-type hold-downs. To guard against this, tighten them snugly by hand.

### Air-pump filter

Aside from the air filter which sits on the carburetor, your car may also have a filter for the air pump. This pump is part of the pollution-control system of your car; its job is to inject ambient air downwind of the exhaust valve to complete the combustion process which began in the combustion chamber.

Most foreign cars, and some domestic vehicles, have an air filter that is similar in appearance to the carburetor air filter. It, too, is equipped with a paper filter element which should be replaced.

Due to the small size of these filters, it is almost impossible to visually inspect them for damage or clogging. Therefore, you should replace these small components at regular intervals or as often as called for in your owner's manual.

FM



# ONLY QUAKER STATE GUARANTEES NEW CAR ENGINE LUBRICATION FOR A LIFETIME. IN WRITING!

## Introducing Quaker State's Lifetime Engine Lubrication Protection Program.

Now Quaker State, the motor oil refined from Pennsylvania Grade Crude Oil, announces the most daring Protection Program available in the oil industry. It's the Lifetime Engine Lubrication Protection Program, the only program to cover your new car's engine for as long as you own it.

This exclusive program is brand new. So take a few minutes to read the following. Once you do, you'll see just how much this program can mean to you. We're sure you'll want to take advantage of it...and keep your new car staying on the road with Quaker State.

**Q. Just what is Quaker State guaranteeing?**

**A.** We're not only guaranteeing the quality of our motor oil, but we're guaranteeing that Quaker State will protect so well, if your engine is ever damaged because our oil fails to protect it, we'll pay for repairs or replacement of any or all of these parts: Pistons & rings, crankshaft & bearings, timing chain, rocker arms and pivots, rods and rod bearings, wrist pins & bushings, camshafts & bearings, valve stems & guides (grinding & adjustments excluded), oil pump, push rods, valve lifters, cylinder heads, cylinder lining or bore, distributor drive gear and timing gears or sprockets.

**Q. What do I have to do to get this protection plan?**

**A.** When you buy a new car, light truck or van from a participating dealer, you'll get the protection plan. To keep it in effect, all you have to do is follow these 4 steps:

1. Have all services performed by your new car dealer or other auto service center.
2. Have the oil changed according to manufacturer's recommendations, or at least every 6 months or 6,000 miles, whichever comes first.
3. Have oil filter and air cleaner replaced, and emission control system maintained, according to manufacturer's recommendations.
4. Keep all service records. These must indicate that only Quaker State Motor Oil was used with date and mileage indicated.

That's it. Now when the manufacturer's warranty ends, your Quaker State limited warranty protection begins...and continues for as long as you own the vehicle!

**Q. What won't the guarantee cover?**

**A.** It won't cover defects in manufacture, vehicles used in competition such as racing, damage caused by negligence, collision or abuse, improper installation, or engine parts not lubricated by motor oil.

**Q. Suppose something goes wrong and I'm covered. What do I have to do, and how long will it take for me to collect?**

**A.** All you have to do is notify Quaker State of a claim, by writing or calling collect. (Address and phone number are on the warranty.) Our claim representative will contact you within 24 hours. Provide the claim representative with a copy of your warranty, copies of your service records, and a statement of damage and repair cost from the dealer or any repair shop you choose. If everything is in order, the claim representative will approve the claim and make the payment.

**Q. If I don't have a brand new car, can I still get the Protection Program?**

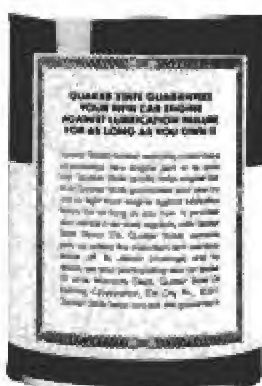
**A.** If your car has under 6,000 miles, you can switch to Quaker State and qualify for the Protection Program at a participating new car dealer's service department. But if your car has more than 6,000 miles, it can't qualify.

**Q. If I buy a new car now, and keep it for 100,000 miles or more, will this Quaker State Protection Program be good for that long?**

**A.** Yes. Lifetime really means for as long as you own your new car—even if you keep it for a lifetime. After all, thousands of people are already driving over the 100,000 mile mark using Quaker State without this protection program. Now, you can do it with Quaker State and have this *extra* protection for as long as you own your new car.

**Q. Why is Quaker State the only motor oil with a written Lifetime Engine Lubrication Protection Program?**

**A.** We've been making quality motor oil since 1910. In all that time, millions of people have depended on our ability to help them stay on the road. All that "on-the-road testing," plus our own laboratory tests through the years, are all the proof we need. Quaker State has the confidence in its product to put our promise of quality in writing.



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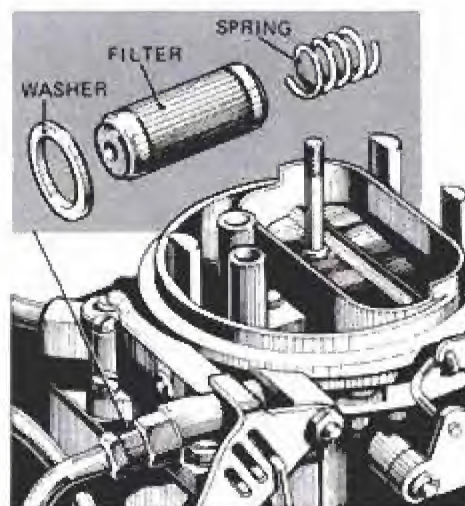
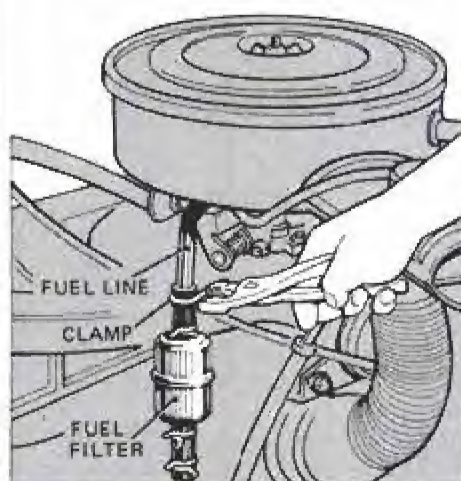
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1981  
**CAR CARE**  
GUIDE

## 9. FUEL FILTER (CONVENTIONAL ENGINE)



The in-line fuel filters have transparent housings so that they may be inspected visually. You must remove the integral fuel filters (shown at right) for proper inspection.

**A** clogged fuel filter causes an engine to exhibit one or more of the following problems:

- Failure to start.
- Rough idling and roughness when driving at lower speeds.
- Lack of power.
- Hesitation on acceleration.

To determine whether the fuel filter of a gasoline engine is faulty, remove the air-cleaner cover from the carburetor. Move the throttle-valve lever back and forth by hand as you peer down the carburetor throat. You should see and hear surges of gasoline being ejected into the carburetor. If you don't, the fuel filter is clogged. Replace it.

### Replacing gasoline filters

Most gasoline engines use one of three types of filters:

- **In-line:** The filter is inserted in the gas line between the carburetor and fuel pump.
- **Internal:** The filter is inserted in the carburetor inlet which connects with the gas line from the fuel pump.
- **In-and-out:** The filter is screwed into the carburetor inlet and protrudes so the gas line can be screwed into it.

Before replacing a fuel filter, place a rag under the filter area to catch any leaking gas. Be sure the engine is cold and turned off. Disconnect the battery ground cable to avoid accidental sparks. And no smoking!

To replace an *in-line* fuel filter:

1. Find the filter, which is a canister inserted in the gas line. It is visible.
2. Using spring-clamp or regular pliers, press the small wire clamps that secure the filter hoses to the gas line. Slide the clamps off the filter onto the gas line.

3. Twist and pull the filter from position. Remove old clamps and hoses and discard them along with the filter.

4. Install the new filter using new clamps and hoses. See that the arrow on the body of the filter points toward the carburetor. Place clamps about 1/4 inch from the ends of hoses to hold the filter securely.

5. Start the engine and check for a leak.

To replace an *internal* fuel filter:

1. Disconnect the gas line from the carburetor. Use two wrenches—one to hold the carburetor-inlet nut and one to turn the gas-line nut.

2. Remove the carburetor-inlet nut and take off the washer, gas filter and spring. Discard only the gas filter.

3. With the opening of the new filter facing outward toward the gas line, install the spring, then the new filter and finally the washer and carburetor-inlet nut. Tighten the inlet nut.

4. Reattach the gas line securely to the inlet nut. Start the engine and check for a leak.

*Note:* Internal fuel filters are used primarily in GM cars.

To replace an *in-and-out* fuel filter:

1. Find the filter. It will be protruding from the carburetor. The gas line may be threaded into the gas filter or it could be secured to the filter by a rubber hose which is held by a clamp.

2. Detach the fuel line from the filter. Either unscrew it, or slide the clamp back and then twist and pull the hose off the filter.

3. Using a wrench, unscrew the filter from the carburetor inlet.

4. Reverse the procedure to install the new filter. **FM**



**ANNOUNCING**

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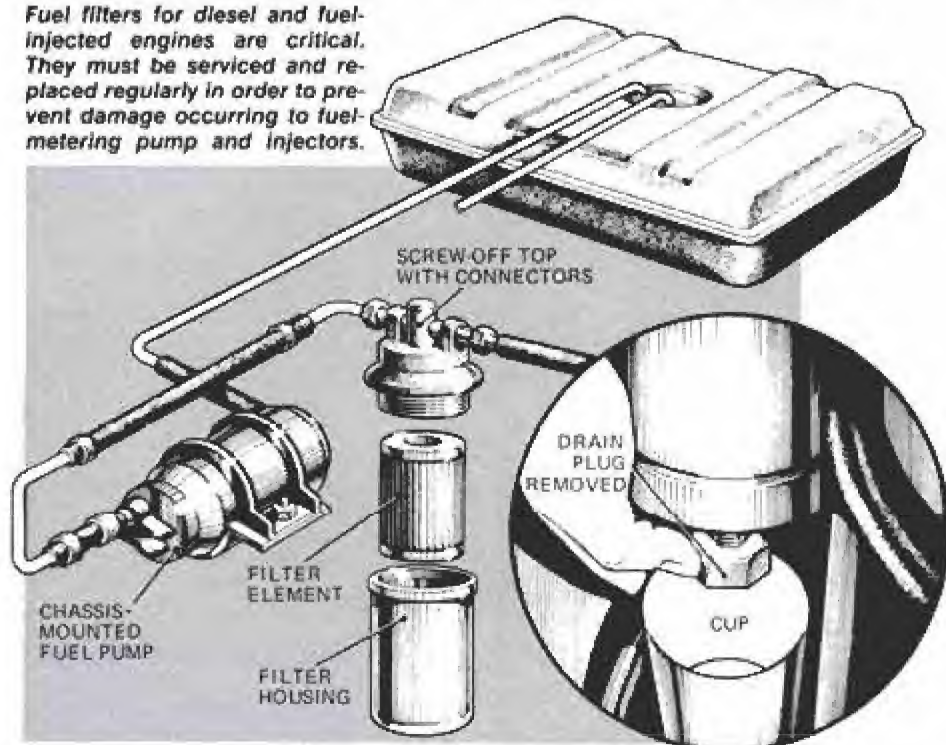
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## 10. FUEL FILTER (FUEL-INJECTED ENGINE)

**Fuel filters for diesel and fuel-injected engines are critical. They must be serviced and replaced regularly in order to prevent damage occurring to fuel-metering pump and injectors.**



**M**anufacturers of engines that use electronic fuel (gasoline) injection (EFI) or diesel technology employ methods of mounting fuel filters that differ from the methods used in conventional gasoline engines. The two examples discussed here pertain to fuel filters for the electronic fuel-injection engine used in the Cadillac Seville and the diesel engine used in Volkswagen Rabbit. Use them as guides when working on other EFI and diesel engines.

To replace the fuel filter in the EFI engine of the Cadillac Seville first disconnect the battery ground cable, and proceed as follows:

**1. Find the pressure-relief valve on the fuel rail near the pressure regulator.** Remove its cap and put a towel under the valve to absorb any gasoline that may spill.

2. To relieve pressure, depress the valve as you would a tire valve.

**Caution:** Releasing the pressure is an important step. If it's not done, gasoline will spray out when you loosen fuel-filter fittings.

**3. Find the fuel filter canister.** It's on the fuel-tank side of the fuel pump.

**4. Unscrew the bottom cover of the fuel-filter canister and take out the paper filter.** Replace it with a fuel filter of the same kind. Also replace the gasket.

**5. Screw the bottom cover on hand-tight.** Turn the ignition key on and off several times to build pressure back into the system. Then check for fuel leaks around the canister.

Replacing the fuel filter of a Volkswagen Rabbit diesel engine is a similar task.

**1. Find the filter canister, which is on the right (passenger) side of the engine compartment near the fire-wall.**

**2. Wrap a band-type oil-filter wrench around the filter canister body, and loosen it.**

**3. Discard the old filter.**

4. Lubricate the seal of the new filter with a thin coat of diesel fuel.

**5. Install the new filter into the canister and screw it back onto its fitting. Hand-tighten the canister.**

Volkswagen recommends that you drain the fuel-filter canister to get rid of water which may have built up. Do this midway between recommended filter changes—that is, every 7,500 miles, since VW recommends replacing the filter every 15,000. To drain the canister, proceed as follows:

**1. Loosen the vent screw.** If there is no vent screw, disconnect the fuel-return hose.

**2. Open the drain plug on the bottom of the fuel canister and drain off at least one pint of fuel.** Allow the fluid to continue draining until it is no longer cloudy.

**3. If the fuel filter has a primary pump, operate the pump until fuel appearing at the vent screw is free of air bubbles. Then tighten the vent screw.**

If there is no primary pump, close the vent screw or reattach the fuel-return hose. Start the engine and accelerate a few times to clear air bubbles from the fuel line. **FM**

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# 11. AUTOMATIC CHOKE

**A** gasoline engine equipped with a carburetor will display one or more of the following symptoms when an automatic-choke-system malfunctions:

- Hard starting.
- Stalling.
- Rough idling, low-speed stumble.
- Lack of power.
- Black smoke from the exhaust.
- Excessive fuel consumption.

To determine if the automatic choke is causing the trouble, let the engine cool down completely. Then remove the carburetor air filter to reveal the choke valve (plate).

Before starting the engine, tap the accelerator pedal to the floor and release it. The choke valve should close.

Start the engine. The choke valve should open a crack and continue to open gradually as the engine gets warm. After five minutes or less, the choke valve should be wide open.

If the choke plate fails to work this way, don't disassemble the unit yet. The most common cause of choke sluggishness is dirt around the choke valve or on the linkage. Apply carburetor and automatic-choke solvent.

When you have cleaned the parts, do the test again. If the choke still fails to respond, disassemble the unit and examine parts.

## Replacing choke-system parts

Generally, there are two kinds of automatic chokes: those with a piston and those without.

For several years, all chokes, piston or not, have been equipped with an electrically heated element to open the choke valve in a short time. This element reduces the period of time the engine runs on a rich fuel mixture. By causing the choke valve to open as soon as possible, the heating element helps reduce emissions that a rich fuel mixture produces. The heating element is a good place to begin.

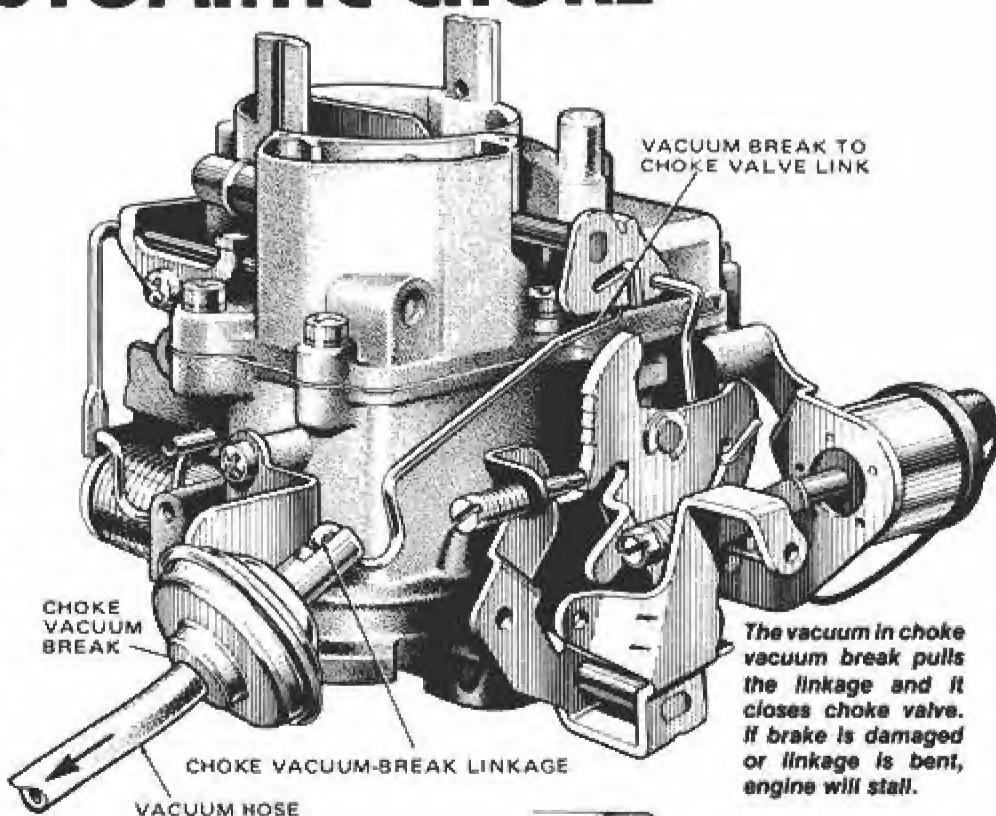
**1. Pull the wire off the terminal of the heating elements with the engine running.**

**2. Hold the wire as close to the terminal as possible without its touching.** There should be a spark. If there isn't, the wire may be faulty, so replace it. If there is a spark, failure of the choke valve to open fully several minutes after the engine starts may indicate a bad heating element.

If the choke plate fails to open slightly as soon as the cold engine is started, the problem may be a defective choke vacuum break.

The vacuum break is a chamber housing a diaphragm. The chamber has a vacuum hose connected to it and a link connecting the chamber to the choke valve. To test the unit:

**1. Pull the vacuum hose from the chamber with the engine running.** Hold your thumb over the end of the hose and see if there is strong vacuum (pull). If there isn't, check that the hose is connected at the other



end (vacuum source) and examine the hose. Straighten it if it's kinked.

**2. Turn off the engine, reconnect the hose to the chamber and disconnect the hose from the vacuum source.** Suck in on the end of the hose. The link to the choke plate should move. If it doesn't, replace the chamber.

**3. Press the vacuum-break linkage into the chamber and hold your finger tightly over the end of the vacuum hose.** Let the linkage go. If the linkage moves, there is a hole in the vacuum-break diaphragm. Replace the vacuum break.

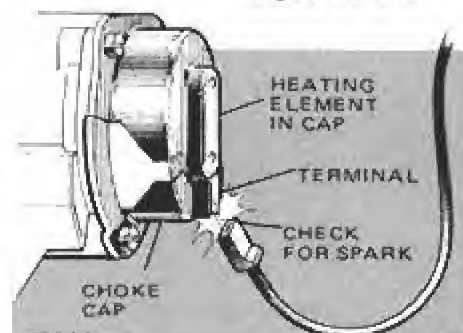
If the trouble with the choke hasn't been resolved yet, look for a choke assembly (called a stove) mounted on the carburetor. Disassemble the unit this way:

**1. Loosen the screws holding the cover to the choke-assembly housing and remove the cover.**

**2. Look inside the cover for the thermostatic spring.** It loses tension as heat is applied to it. This spring, which in time may become weak, is connected directly to the choke valve and controls the movement of the valve. Remove the spring from the cover and squeeze it between your fingers. If it seems to lack resiliency, replace it.

**3. Examine the cover.** If it's cracked, replace it. If there are carbon deposits inside, clean them out with a brush and solvent.

**4. Remove the gasket over the**



**Test electric choke heating element by holding wire near contact. Look for a spark.**

**choke housing.** If there is carbon inside the housing, remove it and replace the gasket.

**5. Examine the heat tube that extends from the housing to the engine.** If the tube is cracked, replace it.

**6. See that the piston found in the choke housing moves freely in its cylinder.** The job of the piston is to open the choke plate slightly when a cold engine is started, so the engine won't load up with fuel and stall. If the piston is binding, free the arm holding the piston and remove the piston. Clean the piston and cylinder with solvent.

**7. Reassemble the unit.** Before tightening choke-cover screws, rotate the cover to the index mark on the housing specified by the manufacturer. Tighten screws and test choke valve functioning as described earlier. **FM**



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This year, Dodge achieves the *best* EPA gas mileage estimates\* with automatic transmission. Improved aerodynamic styling, reduced weight, and the dependable, efficient Slant Six engine all contribute to this Ram 150's superior gas mileage.

## More than Ford or Chevy.

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## 1981 CAR CARE GUIDE

### 12. GLOW PLUGS

In a sense, the glow plugs of diesel engines perform a function similar to automatic chokes in gasoline engines. Both allow cold engines to start quickly. Automatic chokes provide a richer-than-normal fuel mixture, and glow plugs heat up the precombustion chambers to assist in cold-engine starting. When engine temperature gets high enough to ignite compressed diesel fuel, the glow-plug system is deactivated.

Glow-plug systems are tested differently from one engine to another. Some systems require a complicated testing procedure. Other systems, such as the one described here for the Volkswagen Rabbit diesel, are fairly simple to test.

**1. Find the glow-plug system relay.** It is a plug-in unit in the fuse box, under the left side of the dashboard.

**2. Disconnect the wire from the relay to the glow-plug bus bar.** The bus bar is a series of interconnected conductors through which current flows from glow plug to glow plug. You will find the relay-to-glow-plug

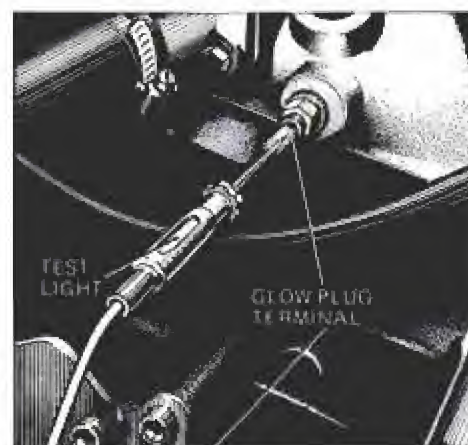
bus bar wire situated at the No. 1 glow plug.

**3. Attach a 12-volt test light to the bus bar wire terminal and to ground.** Turn the Ignition key on. Do not start the engine. Furthermore, the engine should be cold.

If the lamp lights, the problem of hard starting in cold weather probably lies with one or more glow plugs. If the lamp doesn't light, you should hear the relay clicking. If there is no clicking, hard starting in cold weather is probably being caused by a faulty relay. Replace it.

**4. Test the glow plugs by removing the bus bar at the first glow plug and attaching a test light to the battery starter terminal and to the glow-plug terminal.** With the ignition key on (don't start the engine), the lamp should light. If it doesn't, the glow plug is probably bad. Test each glow plug, using the same procedure.

**Note:** In time, carbon may accumulate on the tips of glow plugs and hamper performance. You can remove this carbon with a wire brush.



Glow plugs are tested with a test light. To service them, remove the glow plugs and clean them with a stiff bristle brush.

FM



## 13. FUEL INJECTORS

**A** fuel-injection system (gas or diesel) consists primarily of an injection (fuel) pump and injectors that feed fuel to each cylinder. A faulty injection pump causes:

- Failure to start.
- Rough idling or roughness when driving at lower speeds.
- Lack of power on acceleration.
- Excessive fuel consumption.
- Excessive black, blue or white smoke from the exhaust.

Without equipment that costs several hundred dollars, it isn't possible to test or repair an injection pump.

Troubleshooting injectors is less complicated. If you think an injector is causing an engine problem, loosen the fuel pipe union at each injector, in turn, with the engine running at fast idle speed. Engine speed should change as each fuel pipe union is disconnected.

Removing injectors is similar to removing sparkplugs. However, some engines, such as the Oldsmobile 5.7-liter, require special equipment. Generally, you have to detach front pipes and unscrew injectors.

To verify if an injector is faulty requires use of a pressure pump that measures flow and tests spray pattern. This pump is an expensive tool.

Disassembling injectors for cleaning and repair is not difficult once they have been removed from the engine. Proceed as follows:

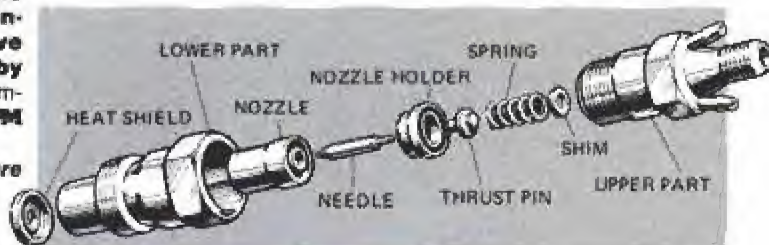
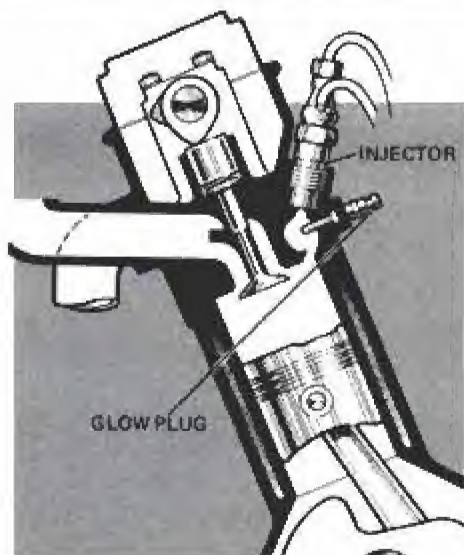
**1. Clamp the top part of the injector in a vise.**

**2. Loosen, but do not remove, the lower part of the injector.**

**3. Turn the injector over and clamp the lower part in vise.**

**4. Unscrew the top part of the injector and remove each part, piece by piece.** Replace damaged parts.

*Injector nozzles are serviced by disassembly, replacement of worn parts.*



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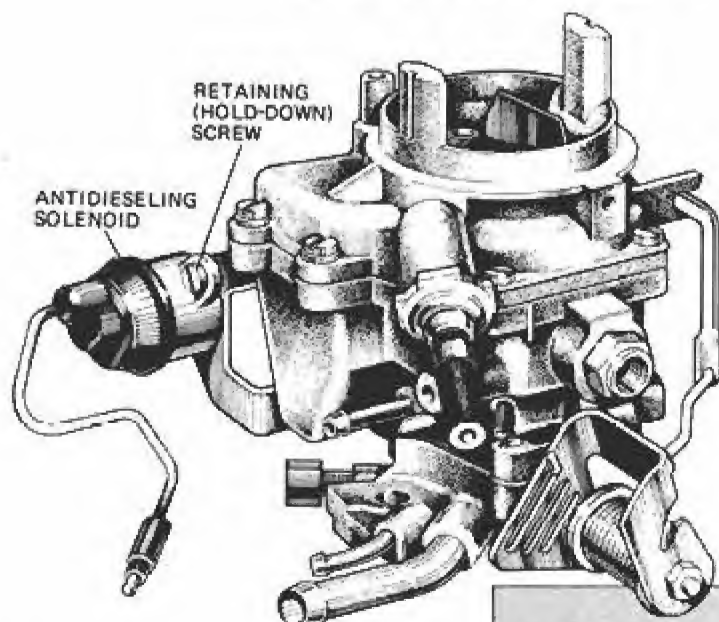


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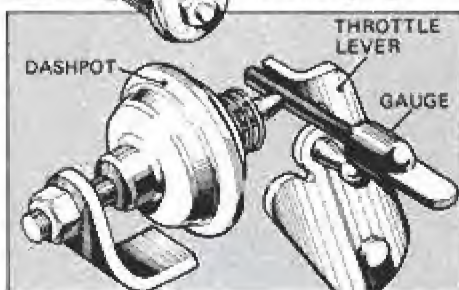
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# 14. IDLE-STOP SOLENOID



*Idle-stop solenoid is malfunctioning when engine runs on after ignition is switched off. To adjust an antistall dashpot (below), you turn the screw at the base. Then check the gap with a feeler gauge.*



The idle-stop solenoid is an electrical part that helps prevent engine dieseling (where an engine continues to chug on after the ignition is turned off). If your car has one, it's on the carburetor—check around the throttle linkage. Most solenoids have a threaded plunger that bears against the throttle-lever arm when the engine idles.

Antistall dashpots (they look like choke vacuum breaks without vacuum connections) are on cars with automatic transmissions. They help prevent stalling by letting the throttle close gradually when you stop after high-speed driving or sudden wide-open throttle acceleration. Stalling under these conditions may indicate dashpot trouble.

To see if you have a dashpot, check the throttle lever. Like the solenoid, the dashpot has a plunger to bear against this lever. If you see a chamber with a plunger near the flange of the lever, it's a dashpot.

## Checking the solenoid

To test your idle-stop solenoid, have someone start the engine and accelerate slightly. The plunger should contact the throttle-lever arm and remain there. Turn off the engine. The plunger should retract immediately, and the throttle should close. If this isn't the case, follow these steps:

1. Turn on the ignition.
2. Pull the wire terminal from the solenoid terminal. Hold it as close as possible, without touching, to the engine or the solenoid terminal. If there is no spark, the wire may be damaged. Replace it.
3. Connect a tachometer and set engine-idling speed by turning the

**Idle-stop solenoid plunger in or out.** Test the unit again. If it fails to function properly, unbolt the idle-stop solenoid and install a new one.

## Working on the dashpot

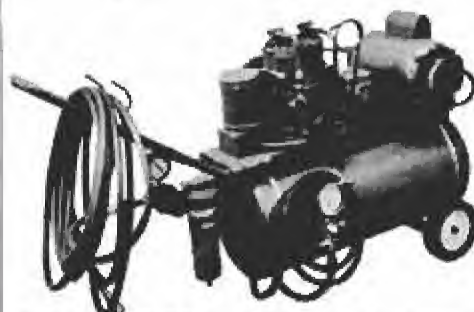
To test the dashpot, warm up the engine and let it idle. Push the plunger into the dashpot until it won't go any farther. There should be about a 1/4-in. space between the plunger tip and the throttle-lever flange. If not, adjust clearance as follows:

1. If the dashpot plunger bears against a capscrew on the throttle lever, insert a 1/4-in. feeler gauge between the tip of the plunger and the screw. Loosen the capscrew locknut, if there is one, and turn screw in or out until it rests on the gauge.

2. Adjust other dashpots by moving the dashpot in or out. Insert feeler gauge between the plunger and throttle lever, loosen locknut holding the dashpot and move dashpot toward or away from the throttle lever.

If stalling continues, readjust the dashpot using a 1/2-in. feeler gauge. If there's still a problem after readjustment, try unbolting the dashpot from the carburetor and replacing it. **PM**

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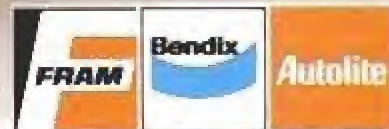


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# 15. FUEL PUMPS

**A** fuel pump that has failed completely prevents engine starting and, more seriously, can cause a breakdown on the road. To find if the fuel pump is bad, remove the air filter and activate the throttle linkage. If no gas squirts into the carburetor, and you've already replaced the fuel filter, the fuel pump is probably faulty. Test it and replace it if defective.

If a fuel pump is faltering and is about to fail, the engine may demonstrate the following:

- Rough idling or roughness at lower speeds.
- Misfire at higher speeds.
- Lack of power.
- Backfiring.

## Mechanical fuel pumps

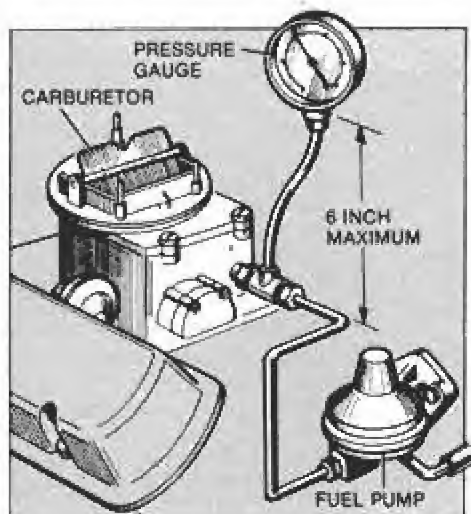
To determine if the malfunction is being caused by the mechanical fuel pump of a gasoline engine, proceed as follows:

**Caution:** Disconnect and ground the high-tension cable from the coil to prevent the engine from starting.

**1. Disconnect the gas line at the carburetor and attach a length of hose to it.** Do this with the engine off.

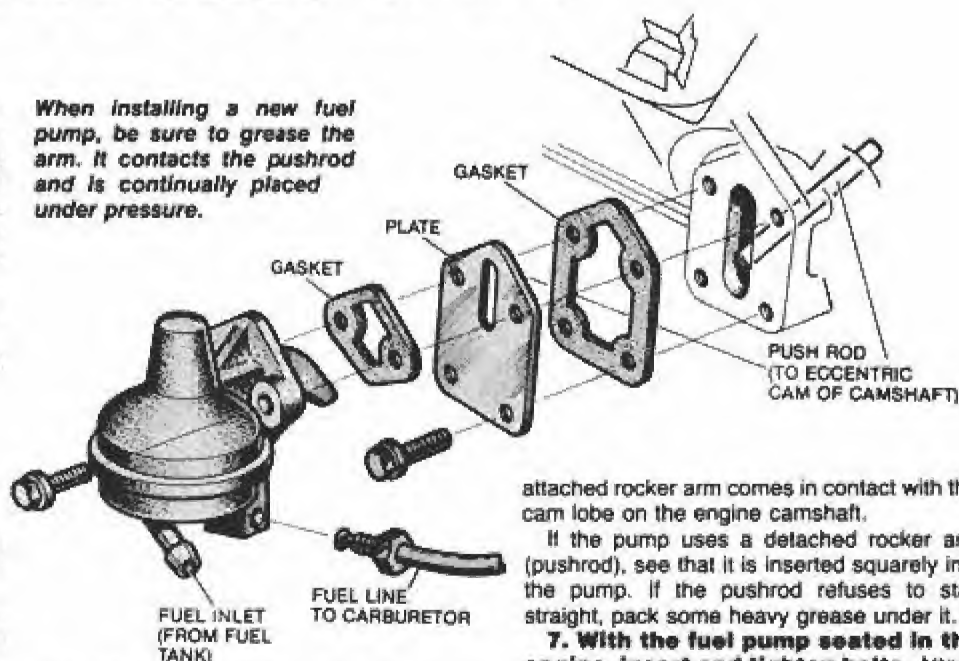
**2. Crank the engine for 10 seconds.** Gas should stream from the hose. If it doesn't, the problem could be with the fuel pump, the gas line on the fuel-tank side of the fuel pump or inside the fuel tank, assuming the fuel filter and gas line from the fuel pump to the carburetor are okay. To check whether the fuel pump is faulty, proceed with testing.

**3. Connect a fuel pump/vacuum gauge as specified in manufacturer instructions.** Generally, the gauge is connected to the carburetor end of the disconnect-



A fuel pump's output is tested with a fuel-pressure gauge tied into the fuel line.

*When installing a new fuel pump, be sure to grease the arm. It contacts the pushrod and is continually placed under pressure.*



ed fuel line. Insert a T-fitting between the carburetor inlet and fuel line and connect the gauge to the T-fitting.

**4. Check service data to determine the manufacturer's recommended pressure for the fuel pump.**

**5. Let the engine idle as you check pressure.** Then shut the engine off. Replace the pump if it fails to attain manufacturer's recommended pressure, or if the gauge needle falls to zero when the engine is shut off.

## Replacing a mechanical pump

Try to reach the pump from inside the engine compartment. If you can't, raise the car and tackle the job from below.

**1. Place a pan under the fuel pump to catch gasoline.**

**2. Remove the fuel lines on both sides of the fuel pump.** The pump may also have a hose from the fuel-evaporation canister or fuel-vapor separator connected to it. Remove this, too.

**3. Take out the bolts holding the fuel pump and remove the pump from the engine.** Notice whether a pushrod is protruding into the pump body from the engine. Be sure it stays in the engine.

**4. Using a scraping tool, clean the fuel-pump seat on the engine.** Old gasket material must be removed.

**5. Coat the fuel-pump seat on the engine with gasket sealer.** Then coat the mounting surface of the new fuel pump.

**6. Place a new gasket on the fuel-pump mounting surface.** Then carefully place the fuel pump back in the engine without disturbing the gasket. See that a fuel-pump-

attached rocker arm comes in contact with the cam lobe on the engine camshaft.

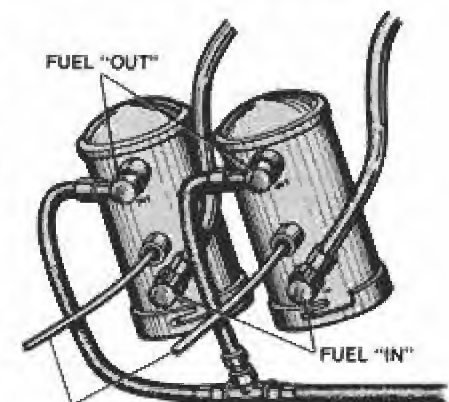
If the pump uses a detached rocker arm (pushrod), see that it is inserted squarely into the pump. If the pushrod refuses to stay straight, pack some heavy grease under it.

**7. With the fuel pump seated in the engine, insert and tighten bolts.** Attach fuel lines, reconnect the coil's high-tension cable, start the engine and check for leaks.

## Electric fuel pumps

If your car has an electric fuel pump, it's mounted somewhere between the fuel tank and carburetor (closer to the tank), or is actually inside the tank. Test electric-fuel-pump pressure as described above. If the pump fails the test, test the electric circuit before replacing the pump. You can do this with relative ease if the pump is mounted externally and you have a circuit diagram.

If the pump is inside the fuel tank, the fuel tank has to be dropped from the car, and the sending unit, which contains the fuel pump, has to be removed from the tank. **PM**



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*Electric fuel pumps cannot be repaired. If they fail when tested, replace them.*



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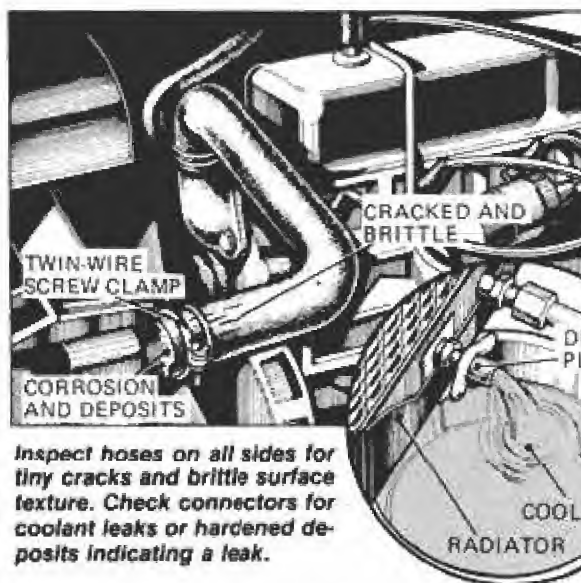
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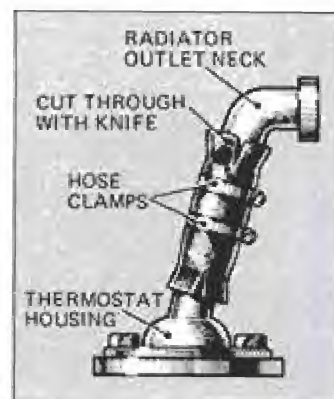
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## 16. HOSES



Inspect hoses on all sides for tiny cracks and brittle surface texture. Check connectors for coolant leaks or hardened deposits indicating a leak.



To remove a hose, cut it with a knife and slide clamps off connector. To replace upper hose, drain coolant to below hose level. If coolant is to be reused, remember to use clean bucket.

**E**very car with a water-cooled engine has at least four hoses: two radiator hoses and two hoses from the engine to the heater. Some engines have a fifth hose, which is a water-pump bypass.

A cooling-system hose can spring a leak. When it does, the engine loses coolant and overheats.

The engine-return hose can give additional trouble.

A problem may occur when the stiffener spring inside this hose weakens. A weak spring can't stop the hose from flattening, particularly when the vehicle is driven at high speeds and pressure against the walls of the hose is great. The restricted hose cuts off coolant to the engine, which then overheats.

A wise car owner doesn't wait for a hose to fail before replacing it. Check hoses every six months and replace those that are cracked, brittle, swollen, excessively soft or that have other failings.

In addition to examining hoses visually and squeezing them to see if they are flexible and resilient, examine the lower radiator hose for proper spring action. To do this, warm up the engine and have an assistant run the engine at high speed. Keep your eyes on the hose. If it flattens, replace it.

### Replacing hoses

To replace a radiator hose, do this:

**1. Open the radiator drain plug and drain coolant until the level is below the hose which has to be replaced.** If coolant is clean and less than two years old, it can be reused. Attach a length of vacuum hose to the radiator drain plug and direct the end of the hose into a clean receptacle.

**2. Loosen radiator clamps and slide them onto the hose.**

**3. Try to pull the hose off its fittings.** If it sticks, slit the hose lengthwise at several points where it attaches to the fitting.

**4. Clean fittings with a wire brush or emery cloth before installing new hoses.** If old clamps are still in good shape, slip them onto the new hose and push the hose onto fittings. If the hose is hard to get on fittings, dip its ends into a pail of hot water. This makes the rubber more pliable.

**5. When the hose is seated, position clamps 1/4 to 1/2 in. from its ends.** Tighten them.

There are four types of hose clamps, as follows:

■ **Spring**—The tangs of this clamp have to be squeezed together so the clamp can be moved. You can use ordinary pliers, but spring-clamp pliers that have notches into which the tangs seat themselves make the task easier. Spring clamps may, in time, lose tension.

■ **Worm screw**—As the screw is turned, a nib engages each successive opening in the clamp. This action tightens the clamp. Vehicle vibration can cause a worm-screw clamp to loosen and coolant to leak. If hoses in your car are held by this type of clamp, tighten the clamps every other month.

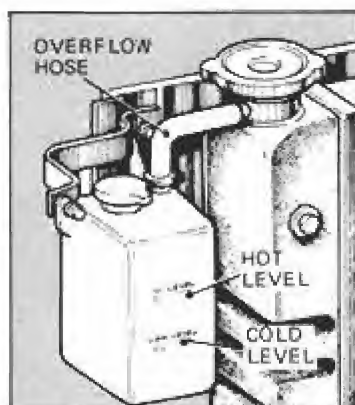
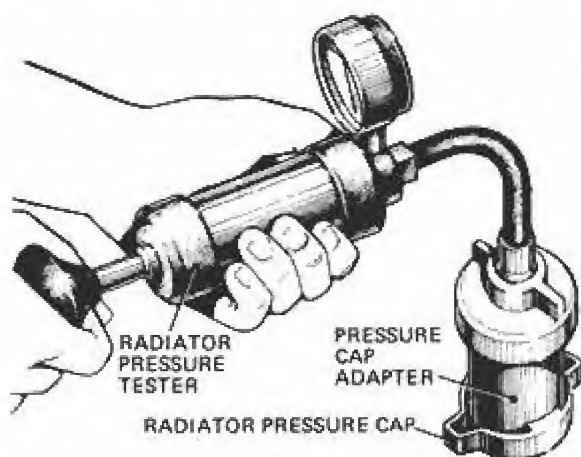
■ **Tower bolt**—As the bolt is turned (using a wrench), a screw device pulls the clamp against the hose. If this clamp is loosened to replace a bad hose, it is usually damaged in the process and cannot be reused.

■ **Twin-wire screw**—When turned, the clamp screw squeezes a pair of wires that tighten around the hose. It provides the most effective clamping. However, be careful not to overtighten the clamp. The wires can cut into the hose.

Any type clamp, or a combination, can be used to hold hoses in any car. **PM**



## 17. RADIATOR CAP 18. OVERFLOW TANK



A cooling-system analyzer applies pressure to the cap as a test for possible leaks. Marks on overflow tank indicate proper levels for both hot and cold coolant.

If a radiator pressure cap loses its ability to maintain pressure inside the radiator, overheating results. Pressure helps raise the boiling point of coolant by approximately 45°F. The extra margin is needed by modern engines, which run at higher temperatures. When there's a loss of pressure because of a weak radiator-cap spring, there is a reduction in the boiling point of coolant. The result, obviously, is engine boil-over.

Test radiator pressure visually and with a radiator-cap tester. Both ways are necessary. A visual test reveals a worn cap and bad gaskets. If they are damaged or worn, or if other damage is apparent, have the filler neck cut out of the radiator and a new one welded in its place.

With the engine cold, try to turn the cap on the radiator filler neck. If the cap has any play, replace it. Also check the tangs on the filler neck. If they are damaged or worn, or if other damage is apparent, have the filler neck cut out of the radiator and a new one welded in its place.

Remove the cap and wash it in water. Then inspect the gasket or gaskets (there may be two—one on the valve spring and one around the inside of the cover). If a gasket is cracked, torn or curled, replace the cap.

**Important:** Every car model uses a pressure cap that has a specific pressure rating. Be sure the cap you buy has the pressure rating specified by the manufacturer of your car. If you get the wrong one, your engine may overheat. An auto-parts and accessories dealer can help if you need assistance.

### Pressure-testing the cap

Visually, the pressure cap may seem to be in good condition, but the true test comes when you submit it to a pressure test.

Using a radiator-pressure tester and cap adapter, perform the test as follows:

**1. Connect the cap adapter to the**

**radiator-pressure tester.** Dip the cap in water to wet the gasket and attach the cap to the adapter.

**2. Examine the cap to find its pressure rating.** Most caps are rated at 13 or 15 p.s.i. (pounds per square inch).

**3. Look at the gauge of the pressure tester while you pump the handle of the instrument to build up pressure.** When pressure reaches the amount that's designated on the cap, stop pumping.

**4. Watch the gauge for at least two minutes.** The needle should not drop below the designated pressure. If it does, replace the cap.

### Removing a pressure cap when the engine is hot

Although you should try to avoid such situations, there may be times when you have to remove a cap from a hot engine. Do this carefully to avoid injury.

Radiator-pressure caps in most cars have to be turned, so pressure is released before the cap is removed. Place a protective cover between your hand and the hot cap—a wadded rag or, better yet, a piece of pliable rubber that's large enough to cover the cap.

Turn the cap slowly until it hits a stop. Don't turn it any farther. Steam and coolant will be released through an overflow hose that juts out from the side of the filler neck.

When hissing ceases, indicating that pressure has been released, press down on the cap and remove it from the radiator.

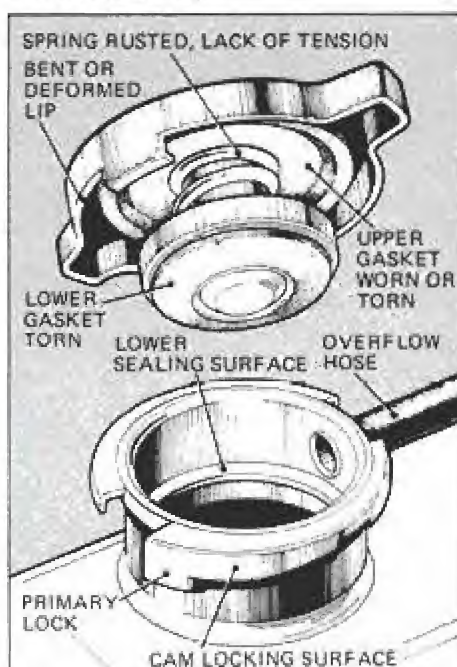
Some radiators have caps equipped with a lever or pushbutton that serves as a pressure relief. With these, you release pressure by lifting the lever or pressing the button. When hissing stops, remove the cap, using a protective cover between your hand and the radiator-pressure cap.

### Overflow hoses and recovery units

As mentioned above, an overflow hose extends from the side of the radiator filler neck. If your car has a coolant-recovery unit, the end of the hose is inside a plastic tank. If your car doesn't have a coolant-recovery system, the end of the hose points to the ground. As the cooling system gets hot and builds up pressure, a spring-loaded outlet valve in the radiator pressure cap opens to allow excess coolant to escape through the overflow hose into the tank or onto the ground.

If the overflow hose extends into a recovery tank, coolant is drawn back into the radiator from the tank when coolant in the radiator cools and contracts. Thus, with a coolant-recovery system, coolant is not lost as long as the system isn't leaking. If you find you are losing coolant, examine the overflow hose and plastic tank for damage. Replace a cracked overflow hose. Be sure it is secured at both ends.

Plastic coolant-recovery tanks are prone to cracking, especially in cold weather. Seal a crack with epoxy. If this doesn't stop the leak, remove the tank from the car and pour off coolant. Insert a plastic bag inside the tank, extending the opening of the bag over the tank opening. Install the tank and screw the cap on so it tightens over the opening of the plastic bag. Coolant flowing from the radiator will empty into the plastic bag.



When you check the cap and filler neck, look especially for worn or bent parts.



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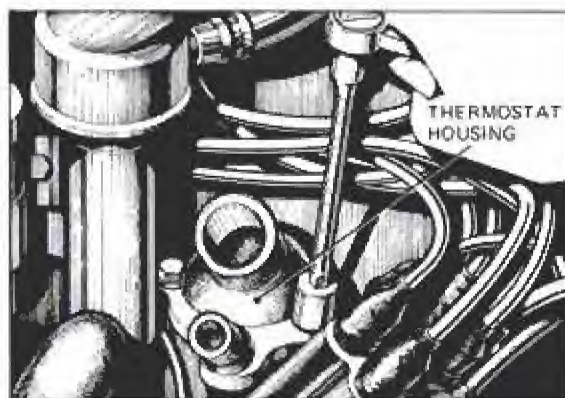
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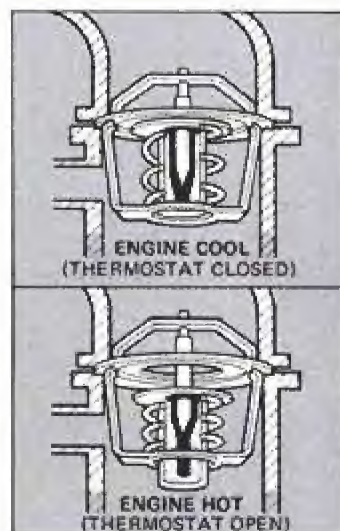


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## 19. THERMOSTAT



To reach the thermostat, first remove the thermostat housing. If the thermostat is faulty, replace it with the correct type. Always be certain that you use a new gasket when you reinstall the housing.



The thermostat is a valve that's normally positioned where the radiator return hose connects to the engine. Hot coolant flows from the engine to the radiator through this hose, which is often called the upper radiator hose. However, in some cars, the thermostat is located at the bottom radiator hose.

When a cold engine is started, the thermostat is closed. Coolant, unable to reach the radiator, recirculates through the engine water jacket. Since it can't give up its heat, as it does when circulating through the radiator, coolant gets hot quickly.

When engine temperature reaches a designated level, the thermostat opens. Hot coolant flows into the radiator, where it is cooled and returned to the engine.

A thermostat valve can bind in the closed or open position. If it sticks in the closed position, the engine overheats.

If the valve sticks in the open position, the engine warms up slowly and may never reach normal operating temperature. Also, the heater does not receive properly heated coolant, so it can't warm the passenger compartment.

To detect a faulty thermostat, remove the thermostat from the engine and test it.

### Removing the thermostat

To remove a thermostat from an engine for testing or replacement, follow these steps:

1. **Drain the cooling system to below the thermostat housing by drawing off about half the coolant in the engine.** Drain coolant into a clean receptacle, so it can be reused.

2. **Remove bolts holding the thermostat housing to the engine and remove the housing.** Usually, you don't need to remove the hose attached to the housing. If the housing sticks to the engine, loosen it by tapping with a hammer. Don't pry under it—you may gouge the housing or engine.

3. **Note the position of the thermostat in the engine, so you can return the old thermostat or its replacement to the same location.** Remove thermostat from engine.

4. **Check to see if the valve is closed by holding the thermostat up to a light.** If you see light between the valve and thermostat housing, replace the thermostat.

5. **If the valve is closed, check the thermostat housing and its temperature rating, as shown on the housing.**

6. **Tie a string to the top of the thermostat.** Extend a rod over a pan of water and secure the thermostat to the rod with the string. Insert a thermometer in the water and put the pan on a kitchen range. Heat the water.

7. **When the water approaches the temperature rating given on the thermostat housing, plus or minus 5°F., the valve should open.** If there is any question in your mind concerning the condition of the thermostat, replace it.

8. **Before installing a new thermostat in the engine, use a putty knife to remove bits of old gasket material from the engine and thermostat-housing surface.** Work carefully. Don't dig into the metal and don't use a screwdriver or chisel for this task.

9. **If you aren't using a self-adhering gasket, spread a thin film of gasket sealer around the housing surface.** Then place the thermostat in the housing and install the gasket. Line up the holes in the thermostat with the holes in the housing. Be careful not to tear or wrinkle the gasket as you press it down. The gasket will hold the thermostat in the housing as you refit the housing to the engine.

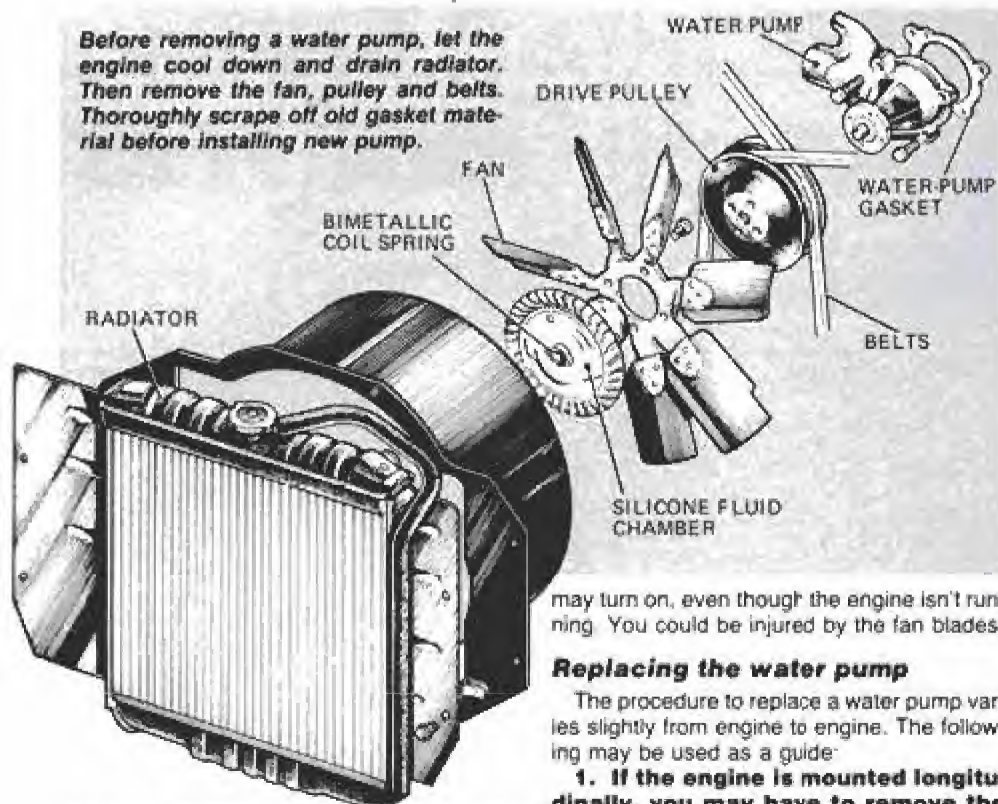
10. **Install and tighten the bolts.** Refill the radiator. Start the engine and check around the housing for leaks.

PM



## 20. WATER PUMP

*Before removing a water pump, let the engine cool down and drain radiator. Then remove the fan, pulley and belts. Thoroughly scrape off old gasket material before installing new pump.*



may turn on, even though the engine isn't running. You could be injured by the fan blades.

### Replacing the water pump

The procedure to replace a water pump varies slightly from engine to engine. The following may be used as a guide:

**1. If the engine is mounted longitudinally, you may have to remove the radiator and fan shroud.**

**2. Remove the water-pump drive belt.**

**3. Make a mark on one of the blades to indicate the front of the fan.** Take out bolts holding the fan to the water pump. Remove the fan, spacer (if there is one) and pump pulley.

**4. Prepare the new pump for installation by coating its mounting surface with a thin layer of gasket cement.** Then place a new gasket on the surface. Make sure you don't tear or wrinkle the new gasket. Press it firmly into place.

**5. Compare old and new pumps, noting distinguishing characteristics, such as vent holes in the bottom.** The new pump must be installed in the exact position of the old pump.

**6. Remove one bolt at a time from the old pump and insert it in the corresponding hole of the new pump.** This procedure assures that the correct bolt, which may differ in size and length from other water-pump mounting bolts, goes into each hole.

**7. When all bolts have been taken out, remove the old water pump.** Scrape off bits of old gasket, making sure the engine's mounting surface is clean. Then apply a coat of gasket cement to the surface.

**8. Push the new pump onto the engine, tightening bolts by hand.** Use a torque wrench to tighten bolts to the maker's specification.

TM

**T**he water pump is the heart of the cooling system. Without it, coolant cannot be delivered from the radiator to the engine and heater and back to the radiator.

When the water pump fails, there is a complete loss of coolant. This results in engine overheating. There is no question of what has happened, because coolant literally flows from the water-pump housing.

The sensible course of action is to inspect the water pump periodically. At the first sign of a leak, replace the pump.

To test a water pump, remove the water-pump drive belt and grasp its pulley in both hands. Rotate the pulley and try moving it in and out. If you feel roughness or grinding, or more than a slightly perceptible in-and-out movement, pump bearings may be damaged. Replace the pump.

Draw your hand around the water pump, just behind the fan. Some seepage is normal. But if there is an unusual amount of coolant, the pump is leaking. Replace it.

**Caution:** A car with a transverse front-wheel-drive engine is generally equipped with a thermostatically controlled electric fan that's placed facing the rear of the radiator. This is not the area of the water pump. It is located at the front of the engine.

Before working under the hood of a car having an electric fan, deactivate the fan. This is normally done by disconnecting the wiring connector from the fan motor or disconnecting the battery ground cable. If left connected, the fan

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The U.S. Department of Transportation recently gave the public a standard yardstick to compare tires by.

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That tire: the Uniroyal Steeler.

In fact, when you translate its 220 rating into projected miles on the government-specified course, you see it was no photo finish.

On that course, the mileage projection for the Uniroyal Steeler is 66,000 miles.

That's 15,000 miles longer than the Goodyear, Goodrich, General and most Firestone ratings in the chart would project.

And 24,000 miles longer than Michelin's rating would project.

These mileage projections (including those in the chart) should be used for comparison only. You will probably not achieve these results. Actual treadlife will vary substantially due to your driving habits, condition of vehicle and, in many sections

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|--|---|-----------|--|
| Manufacturer/Tire:   | Traction and<br>Temperature<br>Resistance | Treadwear |  |
| UNIROYAL<br>Steeler  | B/C                                       | 220       | 66,000   |
| GOODYEAR<br>Custom Polysteel   | B/C                                       | 170       | 51,000   |
| FIRESTONE<br>721 (13" & 14" sizes)                                   | B/C                                       | 170*      | 51,000   |
| GENERAL<br>Dual Steel II   | B/C                                       | 170       | 51,000   |
| B. F. GOODRICH<br>Life Saver XLM                                     | B/C                                       | 170       | 51,000   |
| MICHELIN<br>XWW  | A/B                                       | 140       | 42,000   |

\*Most 15" Firestone 721 tires rated 200 which projects to 60,000 miles.

Source: U.S. D.O.T., 12/19/80.

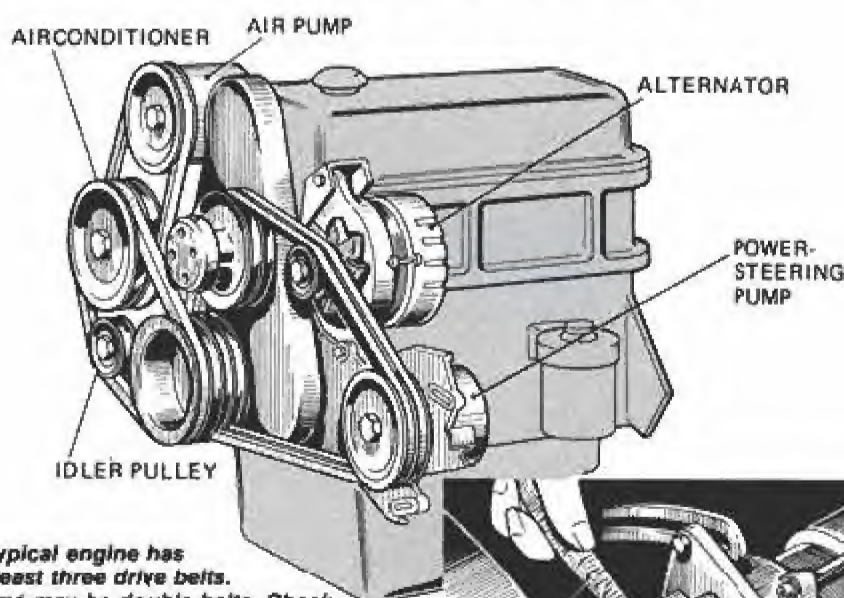
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# 21. DRIVE BELTS



A typical engine has at least three drive belts. Some may be double belts. Check that all belts are in good shape.

Information in this section, although aimed specifically at the water-pump and alternator drive belt (commonly called the fan belt), applies as well to other belts, including the power-steering-pump belt, the air-injection-pump belt and the airconditioner-compressor belt. Depending on the car, as little as one belt and as many as four may be used to operate these components.

## Spotting a faulty fan belt

If the fan belt breaks, the water pump will fail, coolant won't circulate and overheating will occur. If the fan belt also drives the alternator, which is often the case, the alternator won't generate electricity.

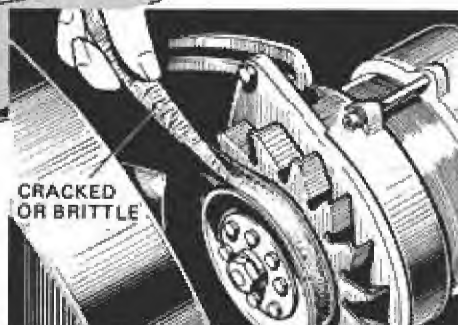
In the case of other drive belts that fail, the particular component the belt serves will not work, whether it's the power-steering unit, air-conditioner or air-injection pump. To avoid an emergency, the time to uncover a bad drive belt is before it fails.

With the engine off, examine belts for the following:

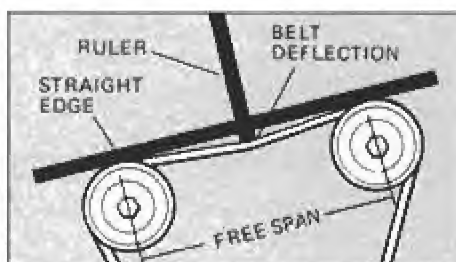
■ Cracks, brittleness, glaze (shiny surface), peeling and a grease coating. Check both the top of the belts and their pulley-side surfaces.

■ Improper adjustment (too loose or too tight). Place a straightedge across two of the belt's drive pulleys and press a ruler down into the belt, midway between the two pulleys. The belt should deflect at least  $\frac{1}{4}$  in., but not more than  $\frac{3}{4}$  in.

If the belt is too loose (which is usually the case, because belts stretch), tighten it. A loose belt often squeals as it rotates. With a loose water-pump/alternator drive belt, engine overheating and a dead battery can occur.



Inspect the underside of belts for cracking and deterioration. Replace if faulty.



Right belt tension will increase life of the belt, as well as that of the accessories.

If the belt is too tight, loosen it before it puts excessive strain on the accessory bearings, causing wear.

## Replacing or adjusting belts

To remove the fan belts in most cars, loosen the bolts that hold the alternator. Push the alternator toward the engine to slacken the belt.

To install (or adjust) the fan belt of most cars, insert a pry bar between the alternator and engine and pull back on the alternator until the belt is tight.

Caution: Lean the pry bar against the solid metal part of the alternator. Do not put pressure on the alternator's cooling fins, which may crack.

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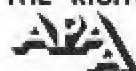
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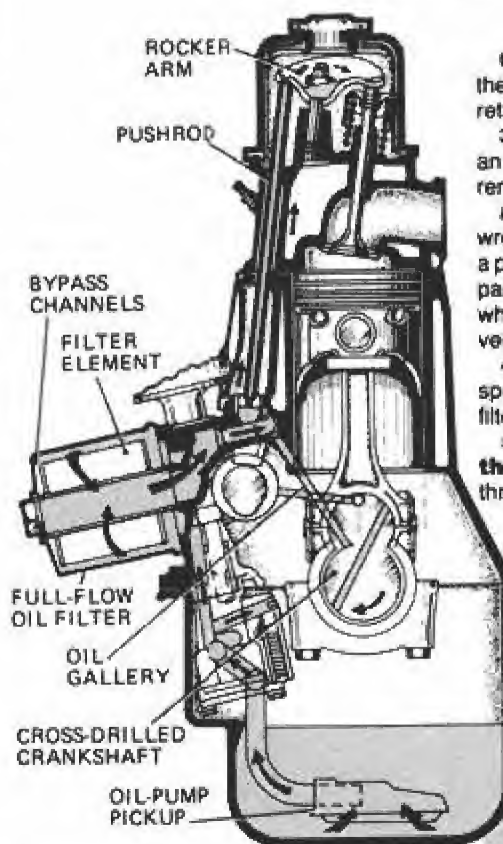
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## 22. OIL FILTER



**Caution:** If the drain plug and washer fall into the drain receptacle, let the oil cool before retrieving them.

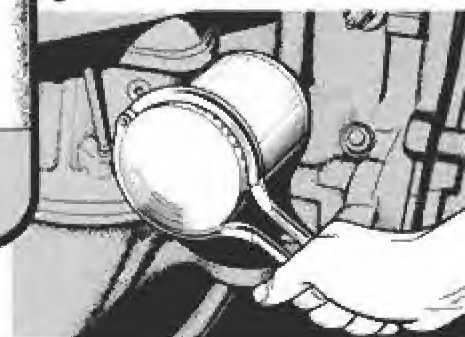
**3. Place a pan under the oil filter.** Use an oil-filter wrench to loosen the filter. Then remove it by hand.

**Note:** There are several types of oil-filter wrenches, each designed to meet the needs of a particular engine design. Check with an auto-parts and accessories dealer to determine which wrench the carmaker suggests for your vehicle.

**4. Dip a clean finger into fresh oil** and spread the oil around the gasket of the new filter.

**5. Turn filter onto threaded pipe of the engine seat.** Be careful not to cross threads.

**6. Spin filter onto the engine until it won't spin further.** Then give the filter an additional one-half turn by



*The oil filter is the most critical part of the lubrication system. Replace it just as often as is called for in owner's manual.*

**S**hort of splitting an oil filter in half, there is no way of telling when one is clogged. Filters possess bypasses that permit oil to keep flowing even if filter passages are blocked. This temporarily prevents major engine damage.

However, if a car owner insists on using a filter clogged with dirty oil, engine life is bound to be affected.

Replace an oil filter as often as the car manufacturer recommends in the maintenance schedule of your owner's manual. Generally, this is every second oil change, the exception being the first time oil is changed in a new car.

However, many Saturday mechanics replace oil filters every time they change oil. They contend that there's no sense mixing fresh oil with the one quart of dirty oil trapped in the filter. There is merit to this argument. Another technique is to remove the filter, drain the dirty oil from it and replace it.

### Installing an oil filter

To install a new oil filter, do this:

**1. Warm up the engine.** Hot oil is thinner and flows more readily than cold oil, which is thick. However, use caution when working around the engine. Parts may be hot enough to cause burns.

**2. Place a large pan under the oilpan drain plug.** Loosen the plug and then remove it by hand. Let the oil drain.

hand. Do not tighten it with the filter wrench.

**7. Wipe the oilpan drain plug and washer with a clean cloth or paper towel.** Install them in the oilpan, being careful not to cross threads.

**8. If you damage the oilpan threads, buy a repair kit.** One type consists of a hollow steel nut, which replaces the original drain plug in the oilpan opening. The nut is open at the end that lies outside the oilpan, and it is self-tapping; that is, as you turn it into the oilpan, it cuts its own threads and seats itself. A brass plug is screwed into the opening in the nut. Remove this plug to change oil. Oil will drain from the oilpan through the opening in the hollow steel nut.

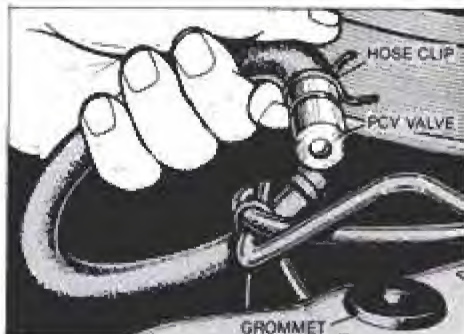
**9. Pour fresh oil into the engine.** Be sure to use the quantity specified by the manufacturer, but note that two quantities are given: (a) the amount to use when the oil filter is not replaced and (b) how much to use when the oil filter is replaced—usually one more quart.

**10. Start the engine, but don't accelerate.** Allow oil to reach bearings before putting stress on the engine. Check around the filter and drain plug for leaks.

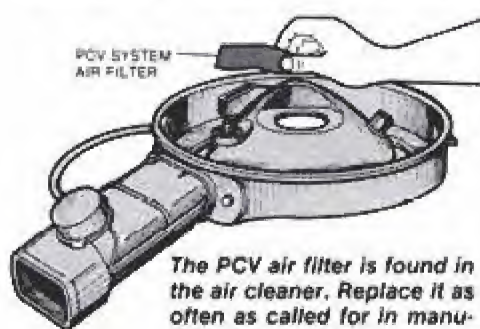
FM



## 23. PCV VALVE



To test a PCV valve, shake it and listen for clicking. If it doesn't click, replace it.



The PCV air filter is found in the air cleaner. Replace it as often as called for in manufacturer's schedule.

**M**ost cars built since 1963, excluding those with diesel engines, have a crankcase-emissions-control system that uses a positive-crankcase-ventilation (PCV) valve. Other cars, however, have a crankcase-emissions-control system that doesn't use a PCV valve. They have hoses and small openings in the engine that divert crankcase emissions to the combustion chambers. For the most part, this non-PCV system is not serviceable.

### Spotting a faulty PCV system

A faulty PCV system causes:

- Stalling.
- Rough idling.
- Oil in the carburetor air cleaner.

### Replacing PCV system parts

**1. Find the PCV valve in the rocker cover.** If you don't know where the valve is located, find the hose from the base of the carburetor or on the oil-fill cap that leads right to it. As long as you're at it, inspect this hose and replace it if it is cracked or kinked.

**2. Start the engine and let it get**

**warm.** Then, with the engine idling, pull the PCV valve from its seat and cover the end of the valve with your thumb. If the valve is working properly and the hose isn't clogged, you will hear a hissing noise and feel suction.

**3. Pull the PCV valve from the hose if there is no noise and suction.** Shake the valve. If it's okay, it will click. If there is no click, replace the valve. If there is a click, replace the hose—it's probably leaking.

**4. Place the valve back in the rocker cover** and disconnect the air inlet hose from the carburetor air cleaner to check the other side of the PCV system.

With the engine running, hold an index card over the end of the hose and wait a couple of minutes. If the card isn't pulled against the hose, the hose or breather cap to which the hose is connected at the other end is clogged.

**Important:** Along with the main air filter, there is a small filter inside most air cleaners. This is the PCV-system air-inlet hose. When this filter is restricted by dirt, idling becomes rough and stalling may occur. Replace the PCV filter periodically.

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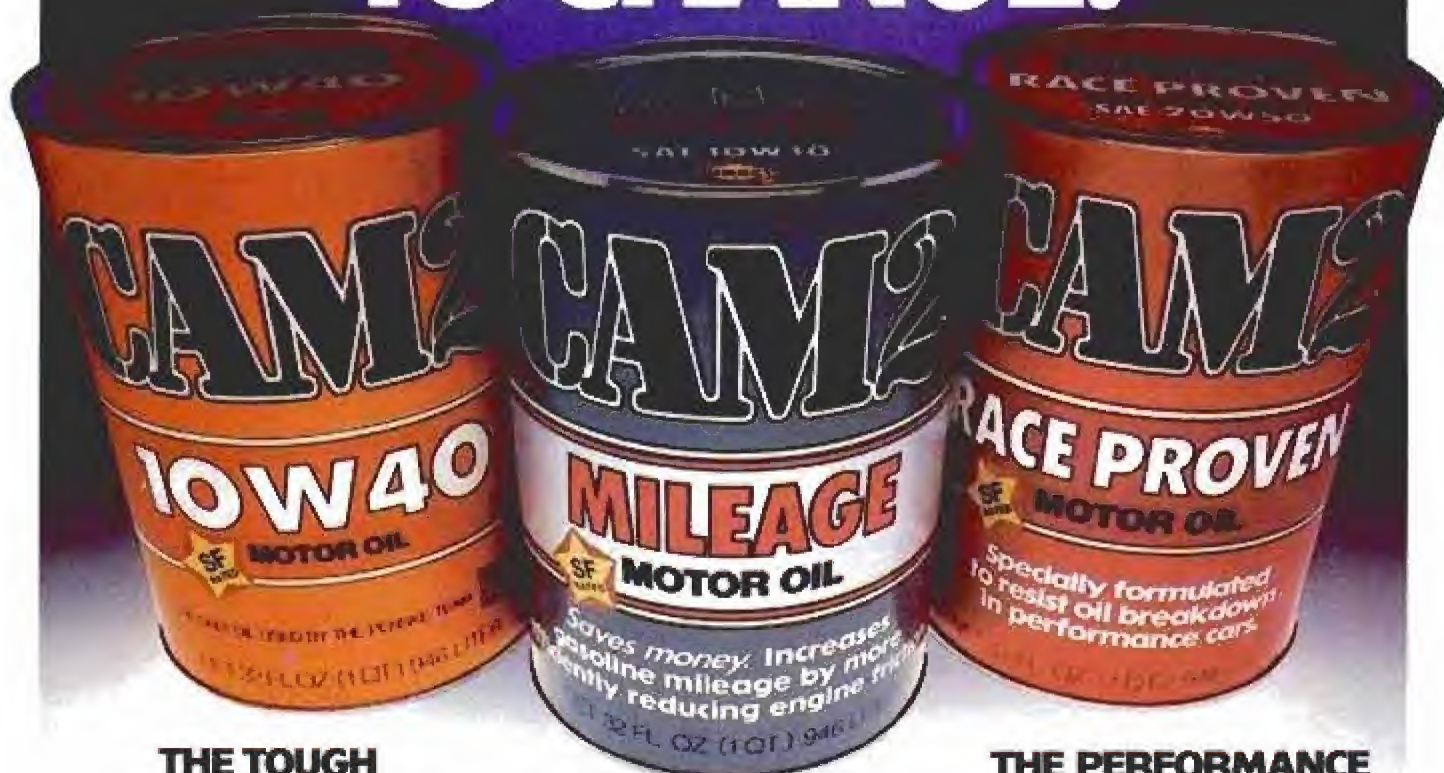
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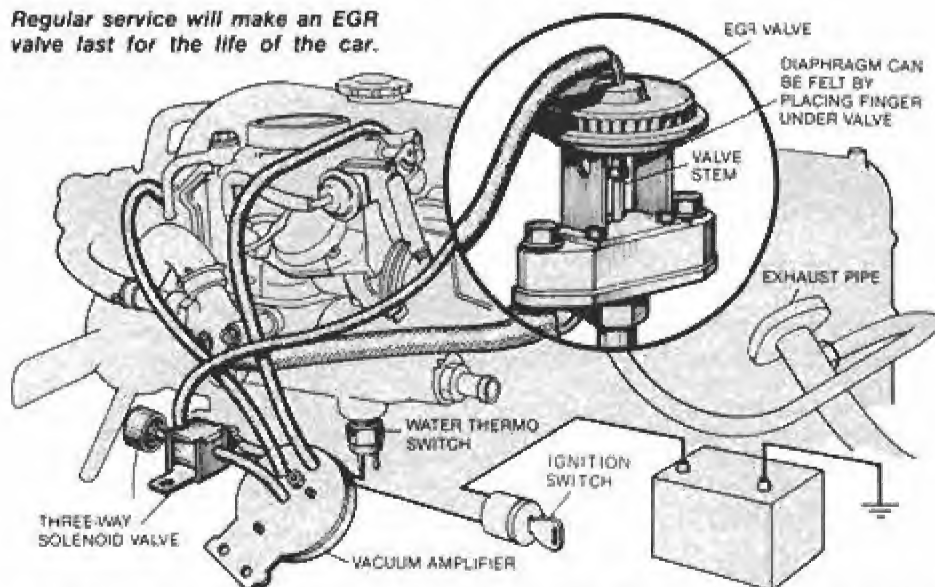
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## 24. EGR VALVE

Regular service will make an EGR valve last for the life of the car.



Most cars built since 1973, including those with diesel engines, possess a vacuum-controlled exhaust-gas recirculation (EGR) valve that injects small amounts of exhaust gases into the intake manifold. These gases mix with and dilute the fuel mixture, which tends to lower combustion temperature. This helps reduce the amount of nitrogen oxide produced by an engine. Nitrogen oxide, a pollutant that forms at high temperature, is instrumental in the development of atmospheric smog.

### Spotting a faulty EGR system

The EGR system consists primarily of an EGR valve, which is located at the rear of the carburetor or on the intake manifold, and a vacuum hose from the valve to a vacuum source on the engine. A faulty EGR valve or hose can cause the following problems:

- Hard starting.
- Stalling.
- Rough idling.
- Misfire at lower speeds.
- Lack of power at higher speeds.
- Hesitation when accelerating.
- Detonation (ping).
- Surging.
- Excessive fuel consumption.

The first step in checking system performance is to warm up the engine and let it run at idle speed. Then twist the vacuum hose from its nipple on the valve and press your thumb over the opening. If you don't feel a strong pull, the vacuum hose is probably defective. Replace it. If the hose is okay, push it back onto the EGR-valve nipple and check operation of the valve.

The stem and diaphragm of most EGR valves are exposed, which permits testing without removing the valve from the engine. These parts cause the valve to open and close, allowing for injection or curtailment of exhaust gases into the intake manifold.

Watch the valve stem as someone in the car

taps the accelerator pedal to provide a quick, momentary increase in engine speed. If the stem does not move, take the valve off the engine for servicing. If the stem moves, the EGR system is probably working.

If the valve stem can't be observed or you aren't sure if it is moving, place the tip of your finger under the valve body. Hold it lightly against the valve diaphragm while the person in the car accelerates the engine. You should feel the diaphragm pulse. If not, take the valve off the engine for servicing.

Numerous incidents of EGR valve failures in GM X-body models (Citation, Omega, Phoenix and Skylark) have come to our attention.

### Replacing the EGR valve

**1. Pull off the vacuum hose and remove the bolts** (there are usually two) **holding the EGR valve housing to the engine.** In most cases, there is a gasket under the housing. If you're careful, you may be able to salvage and reuse the gasket if the valve, after servicing, can be reused. If the gasket is damaged, ask your auto parts and accessories dealer to provide the correct gasket.

**2. Clean away only deposits lodged in ports of the intake manifold—they** may be hampering EGR valve operation. A baby-bottle brush is a suitable tool.

**3. Invert the EGR valve and examine passageways for carbon deposits.** Use a small stiff-bristle brush or penknife to get them out. Rapping the base and side of the valve with a plastic-headed hammer may help loosen them. Watch out for the diaphragm. If you accidentally tear into it, replace the assembly. The EGR system won't work if the diaphragm is damaged.

**4. Reinstall the valve and reconnect the vacuum hose.** Test the assembly again. If it still isn't working right, replace the valve. A bad diaphragm or some other damage is probably causing the problem. **FM**

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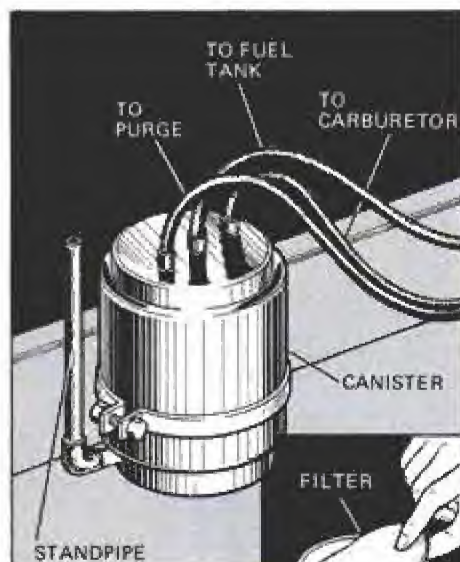
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## 25. CHARCOAL CANISTER



Other than the charcoal itself, the only other part that can be replaced on the canister is the filter element.

**M**ost cars built since 1971, excluding those with diesel engines, have an evaporative emissions control (EEC) system. It consists of a charcoal canister which absorbs fuel vapors from the fuel tank and carburetor when the engine isn't running, instead of letting them enter the air. When the engine is running, vapors are pulled by vacuum from the canister into the engine through the intake manifold and are burned.

### Spotting a faulty EEC system

An EEC system consists of the charcoal canister and hoses that divert fuel vapors from the fuel tank and carburetor into the canister. An additional hose draws vapors from the canister into the intake manifold.

Most charcoal canisters have a filter, usually made of fiberglass, to trap dirt from air drawn into the canister as the engine is running.

If there is a strong gasoline odor in the car and under the hood, a defective EEC system may be the cause. Inspect hoses and the canister for damage. If a filter is used, replace it. If

the odor still persists, the canister may have to be replaced.

### Replacing EEC system parts

To replace a filter or canister, do this:

**1. Find the charcoal canister.** In most AMC, Chrysler and GM models, it is on the inner pan of the right fender, near the radiator. On most Fords, it is near the crankcase.

**2. Mark each hose with a different number** and each hose nipple on the charcoal canister with a corresponding number. Use masking tape. Then disconnect hoses. *Note:* You needn't disconnect the hoses if you take care not to tear or kink them.

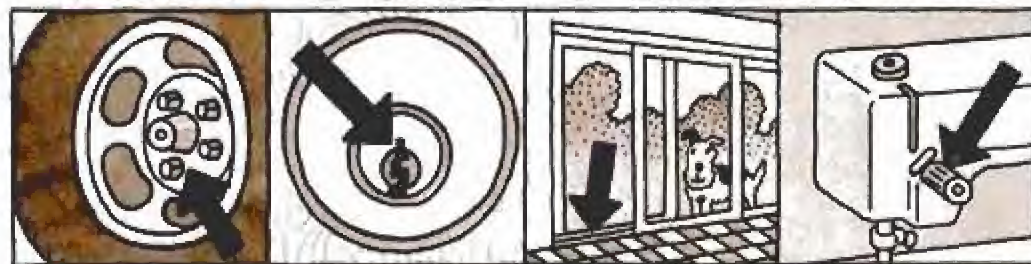
**3. Loosen the bracket holding the canister.** Slip canister off the bracket.

**4. Inspect canister.** Replace it if it's cracked.

**5. If the canister is in good condition, turn it upside down and draw the filter from the holder, if there is one.** Install a new filter. Then replace the canister and reconnect the hoses.

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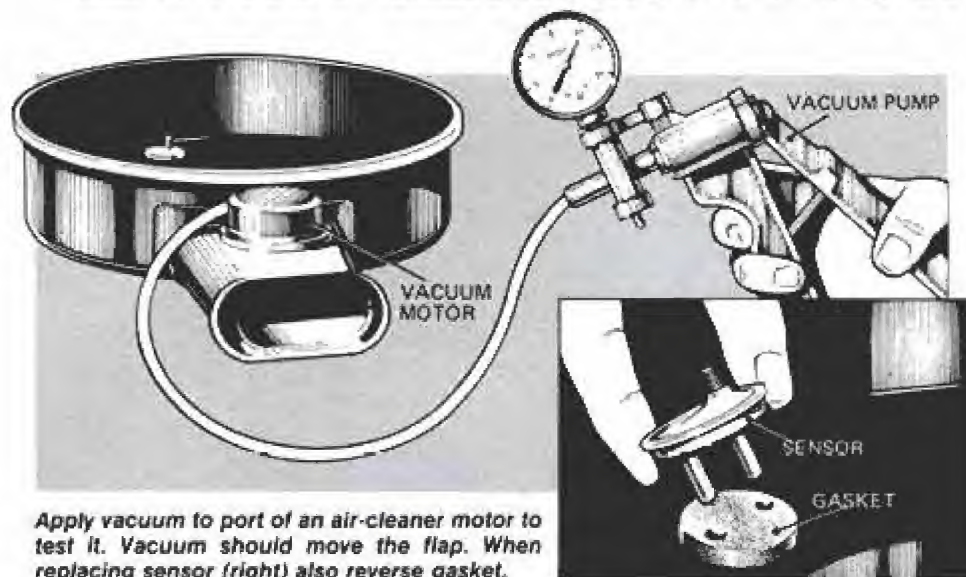
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# 26. AIR CLEANER MOTOR 27. SENSOR



Apply vacuum to port of an air-cleaner motor to test it. Vacuum should move the flap. When replacing sensor (right) also reverse gasket.

**M**ost cars built since 1968, excluding those with diesel engines, have a thermostatic air cleaner (TAC) that helps reduce the output of hydrocarbons. The unit keeps the temperature of air entering the carburetor at between 90° and 105° F., regardless of ambient temperature. Maintaining carburetor intake air at 90°-105° F. allows the engine to run on a leaner fuel mixture as it's warming up, permits more rapid engine warm-up and reduces the chance of carburetor icing.

## Spotting a faulty TAC system

A faulty TAC component causes one or more of the following engine problems:

- Stalling.
- Rough idling.
- Missing.
- Hesitation.
- Surging.
- Lack of engine power.
- Poor gasoline mileage.

Components that should be checked are the temperature sensor, vacuum motor, vacuum hoses, damper door and hot-air pipe. In some car models, the hot-air pipe extends from the exhaust manifold to the front of the TAC snorkel. In other models, the hot-air pipe extends from the exhaust manifold to the bottom of the snorkel.

Begin by examining vacuum hoses and the hot-air pipe for splits, kinks and tight connections. If you can find any damaged parts, replace them.

Now, warm up the engine and let it idle. Remove the air-cleaner cover and filter. Place a cold, wet rag over the temperature sensor as you keep your eye on the damper door in the snorkel. (If the snorkel opening has the hot-air pipe attached to it, disconnect the pipe from the snorkel after the engine has warmed up so you can see the damper door.)

If the damper door closes, as it should, remove the wet rag and reinstall the air-cleaner cover and filter. The damper door should now open. If it does not, replace the temperature sensor.

If the door doesn't close when the wet rag is applied or the TAC seems to operate as it should for this test, but the engine problem still exists, continue by disconnecting the vacuum hose from the nipple on the motor. Attach a hand vacuum pump to the nipple and apply vacuum to the motor as you watch the damper door. The door should close.

The actual amount of vacuum needed to open the damper door varies with the system, but is between 9 and 20 inches. Thus, if the door does not close by the time the hand vacuum-pump gauge shows 20 inches of vacuum, the motor isn't working. Replace it.

There is a chance that the door is binding. To find out, stick a screwdriver inside the snorkel and press against the door. It shouldn't require much force to activate the door. If it does, squirt some solvent at the door, concentrating on the pivot points. Use your screwdriver to work the door open and shut to spread solvent into the joints. Then do the test again.

If the door is damaged you'll have to replace the air cleaner, if you can't replace just the snorkel. Ask your auto-parts and accessories dealer whether the snorkel of your air cleaner is available as an individual part.

## Replacing the TAC sensor

Generally, sensors are removed as follows or in a closely similar manner so you can use this information as a guide:

**1. Take the TAC off the carburetor.** There are several hoses attached to the modern carburetor. Avoid a problem during reinstallation by using a code system to identify each hose to its fitting.

**2. Turn the air-cleaner housing upside down** to get at the retaining clips holding the sensor.

**3. Slip a screwdriver under each retaining clip and pry it off.**

**4. Invert the housing and remove the sensor and gasket.** Discard old parts, including retaining clips. A new sensor is equipped with a new gasket and retaining clips.

**5. Place the new gasket on its seat in the housing and install the sensor.**

**6. Hold the sensor in place and tip the housing** so you can get retaining clips on the sensor legs. Be sure the sensor is pressed down so the gasket is compressed to make an airtight seal. Lock the sensor to the air cleaner.

## Replacing the vacuum motor

Some vacuum motors are held in the snorkel by tabs that lock into slots. You won't see rivets or welds and will be able to move the motor. To replace this part, proceed as follows:

**1. Disconnect the hose from the motor.**

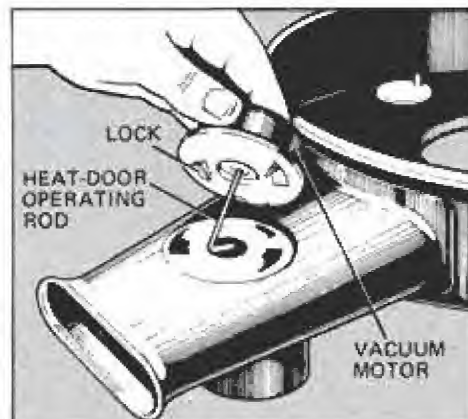
**2. Rotate the motor counterclockwise** to disengage it from the lock in the snorkel.

**3. Pull up and slide the motor to one side** to disengage the operating rod from the damper door. Remove the motor.

**4. Replace the motor.** Insert the operating rod into the slot in the damper door. Place the tabs of the motor into the openings in the snorkel and turn the motor clockwise to lock the motor in place. Attach the vacuum hose.

A vacuum motor welded to the snorkel or held by rivets is replaced in the same way, except that the welds or rivets have to be broken by drilling them. The new motor comes with sheet-metal screws, so you don't have to reweld or rivet.

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To remove a vacuum motor, pry open the lock tabs to free it from the air snorkel.



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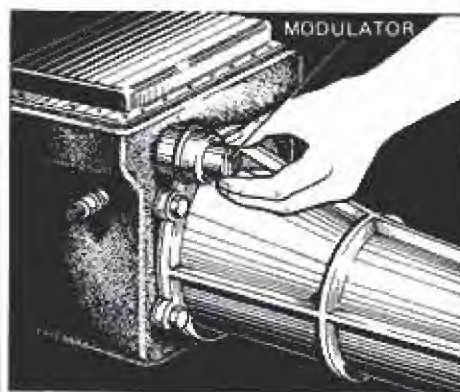
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## 28. VACUUM MODULATOR



In most cases, the vacuum modulator is located at the right rear of transmission.

Not all automatic transmissions have modulators to control the shifting of the transmission according to the strength of engine vacuum. Some transmissions have a linkage from the carburetor to the transmission, which serves the same purpose.

The best way of finding out whether your transmission is fitted with a modulator is to inspect the transmission housing. If a modulator is present, it will be screwed into the side of the housing, and there will be a vacuum hose (or hoses) leading from the modulator to the intake manifold or some other vacuum source.

A faulty vacuum modulator causes one or more of the following problems:

- No drive to the wheels.
- Transmission slips.
- Transmission shifts erratically.
- Transmission shifts roughly.

### Replacing the modulator

First, make sure the vacuum hose (or hoses) has not vibrated loose. This could be causing the trouble.

Next, inspect the vacuum hose (or hoses) for cracks. Replace a bad hose.

Finally, pull the hose (or hoses) from the modulator and run a screwdriver inside it. If the screwdriver shank comes away wet, the modulator is leaking. Replace it.

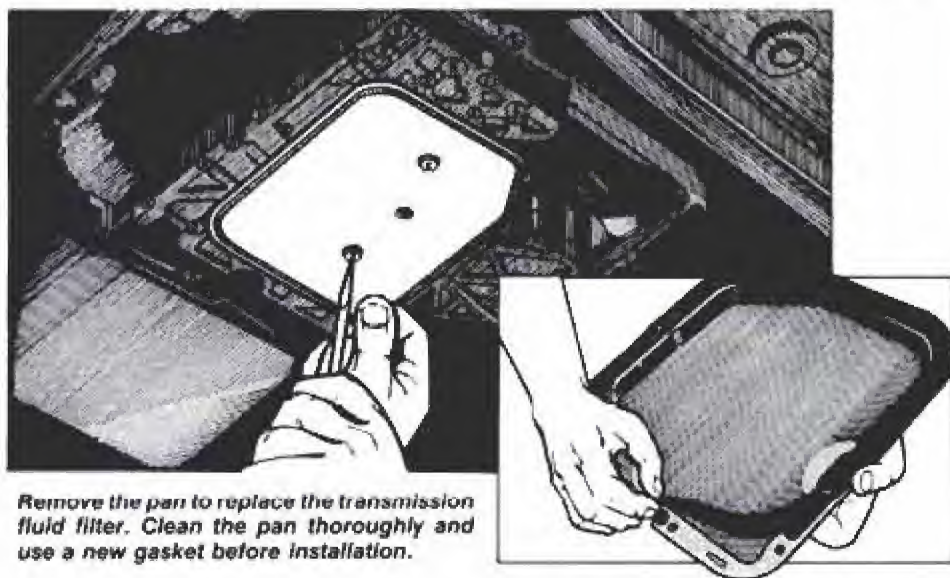
To replace the modulator, drain the transmission. Some units have drain plugs. With others, you have to drop the transmission pan. Unscrew the modulator from the transmission. If the modulator is held by a metal bracket, unbolt the bracket and pull the modulator from the transmission.

Note if the modulator has a metal pin and O-ring. If it does, retrieve these parts. They can be reused. Install a new modulator.

Some foreign cars have a manual kickdown in conjunction with a vacuum modulator. This is a mechanical linkage system connected to the throttle, which kicks the transmission into a lower gear. If your car isn't shifting properly, you should also examine this system and adjust it.



## 29. AUTOMATIC TRANSMISSION FLUID FILTER



Remove the pan to replace the transmission fluid filter. Clean the pan thoroughly and use a new gasket before installation.

**A** dirty transmission filter will not cause a malfunction. However, the filter does play an important part by helping to keep the transmission fluid clean. It protects the delicate transmission parts by filtering all foreign matter out of the fluid before it can cause any serious damage.

According to the Automotive Information Council, "Drivers ignore the maintenance of their automatic transmissions more than any other car component. Prolonged neglect can lead to a repair or overhaul costing up to several hundred dollars."

### Checking fluid level, color

The best way to determine when your transmission is due for servicing is by checking the maintenance schedule in the owner's manual. The manufacturer may require maintenance every 24 months or 24,000 miles, every 36 months or 36,000 miles, or never if the car isn't driven under adverse conditions. These adverse conditions include such things as towing a trailer or driving in mountains, deep snow or mud.

However, when you check the transmission-fluid level, pay attention to the color of the fluid. This should be red or maroon. If the fluid looks brown, don't wait for the recommended service interval. Change the fluid and filter right away.

### Replacing fluid and filter

**1. Remove the drain plug and allow the fluid to drain.** If there is no plug, loosen (but don't remove) the oilpan bolts. If the pan sticks to the transmission housing, pry it loose with a putty knife.

When the fluid drains, you should try to catch as much of it as you can in a suitable large receptacle, so that it can be disposed of properly.

**2. Remove the oilpan and filter after the fluid has drained.** The filter may be held by screws or clips.

**3. Clean the filter in solvent and reuse it if yours is a metal, screen-type filter.** If the filter is a cloth type, buy a new one. Be sure that you consult with the auto-parts and accessories dealer so that you'll get the right filter. At the same time, purchase a new gasket and transmission fluid of the same quality and type that's recommended by the car manufacturer.

**4. Scrape the old gasket material from the oilpan and transmission housing with a putty knife.** Then clean the oilpan in solvent. If any dirt is left in the pan, it could be transferred to a transmission part and cause damage.

**5. Lay the new gasket carefully on the pan so that the bolt holes will line up.** Then you can install the filter in the transmission.

**6. Hold the oilpan up to the transmission housing and install the bolts finger-tight.** Then tighten them securely with a wrench, using a crisscross sequence.

**7. Install the drain plug if the oilpan uses one.**

**8. Add new fluid through the transmission fill tube in the engine compartment.** Use a clean funnel. Don't add any more fluid than is necessary to bring the level up to a point between the ADD and FULL marks on the dipstick.

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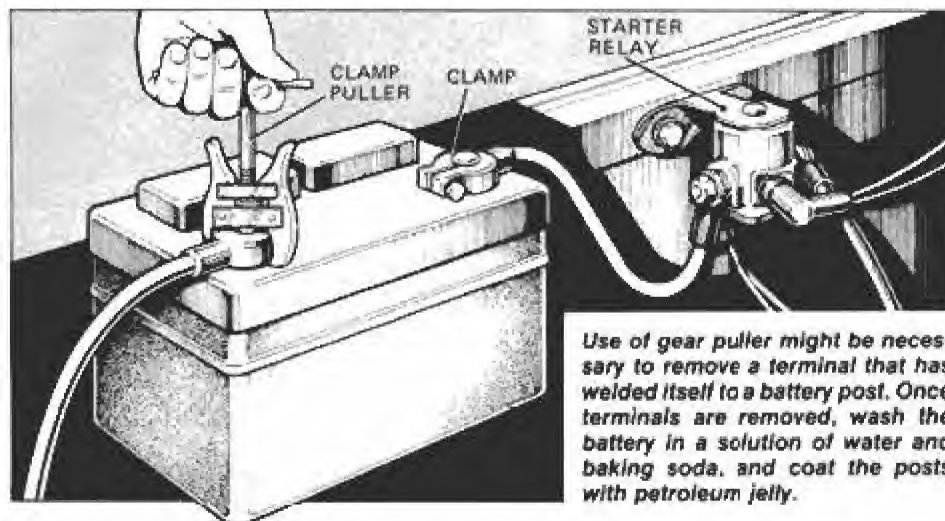
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## 30. BATTERY 31. CABLES



The starter motor won't work and the engine won't start when a battery is weak or dead, or when a battery cable is damaged or corroded. However, there may be a clicking sound as the ignition key is turned. Signs of impending battery trouble are a flashing alternator warning light and dim headlights.

To determine whether a battery is discharged and, if so, whether it can be recharged, do a hydrometer test. This can be done only if battery vent caps are not sealed.

If your car has a battery with sealed vent caps (maintenance-free battery), it may have an indicator to tell if the battery can be charged. An all-dark indicator means the battery can be charged. If it's pale or yellow, the battery is dead and should be replaced. A light-green dot against a dark background suggests the battery is probably not to blame for an engine problem. However, you can charge it to be sure.

Some maintenance-free batteries have no indicators. These may be tested with a voltmeter that can read 1/100 of a volt. If voltage is less than 12.4 volts, charge the battery.

As for cables, inspect clamps for corrosion. If it's present, remove clamps from battery posts for cleaning. You may need a special tool if clamps are so badly corroded they have welded to the posts.

Never bang on clamps to loosen them. You'll damage battery posts, ruining an otherwise good battery. Instead, place a clamp-puller tool under the clamp and tighten it. As you do, the jaws will loosen the clamp from the battery post. You can buy this tool at an auto parts and accessories store.

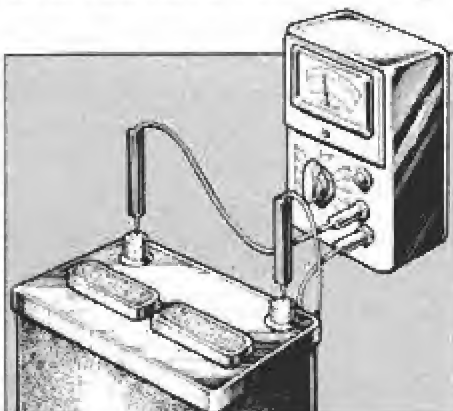
Clean the clamps and battery posts with a wire brush. A special battery-cleaning tool is also available at auto-parts and accessories stores. One end is for cleaning clamps; the other for battery posts.

When clamps and posts are clean, refit and tighten clamps to posts. Try starting the engine. If this is still a problem, check cables. Replace either or both if insulation is cracked.

The negative cable is usually attached to the engine and a negative battery post. The positive cable is connected to the starter solenoid or starter relay and to the positive battery post. Before attaching a new cable, clean the connecting points. Connections must be tight. If cables are in good condition, turn to the battery.

### Making a hydrometer test

1. **Remove cell caps.**
2. **Insert the hydrometer into a cell.** Squeeze the bulb to draw enough electrolyte into the tube so the hydrometer scale floats. Don't draw in too much—the scale may jam against the top of the tube and prevent an accurate reading.
3. **Hold tube so the scale is at eye level.** Read scale and record the reading.



Use a voltmeter to check battery voltage. Test after the battery has been charged.

### 4. Return the electrolyte to its cell.

Take readings from each of the other five cells in the same way. *Note:* Use a hydrometer with a built-in thermometer that makes temperature corrections automatically. The thermometer spells out how many points to add or subtract from the reading, depending on temperature of the electrolyte. Other hydrometers are not as accurate.

5. **Compare each cell reading with the others.** If there are more than .050 points between any of the readings, replace the battery. Such a difference indicates the existence of a short circuit.

6. **Average the readings.** Charge the battery if the average reading is less than 1.230. Then retest. If the average reading doesn't increase, the battery is not taking a charge and will soon have to be replaced. A fully charged battery should have a reading of 1.260 or more.

### Handling a battery

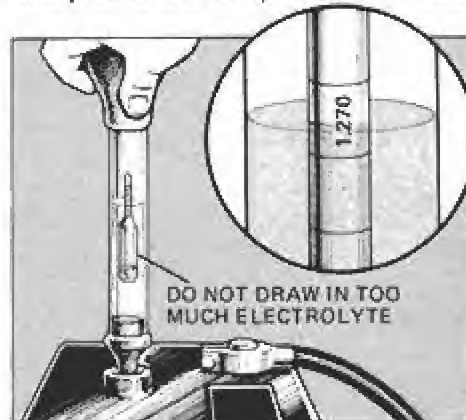
To remove a battery from your car, first undo hold-down clamps which keep the battery from vibrating. If hold-down clamps are rusted and difficult to loosen, use penetrating oil and a wire brush to try to free them. As a last resort, you may have to cut the hold-downs with a hacksaw. Replacement battery hold-downs are available.

Use a lifting strap to lift and carry a battery. Don't lift it by hand. A battery is heavy and can easily slip. If it falls to the ground, chances are it's going to be damaged, and a physically damaged battery must be replaced.

One kind of lifting strap attaches to a battery with top-mounted posts; another type of strap attaches to a battery equipped with side terminals.

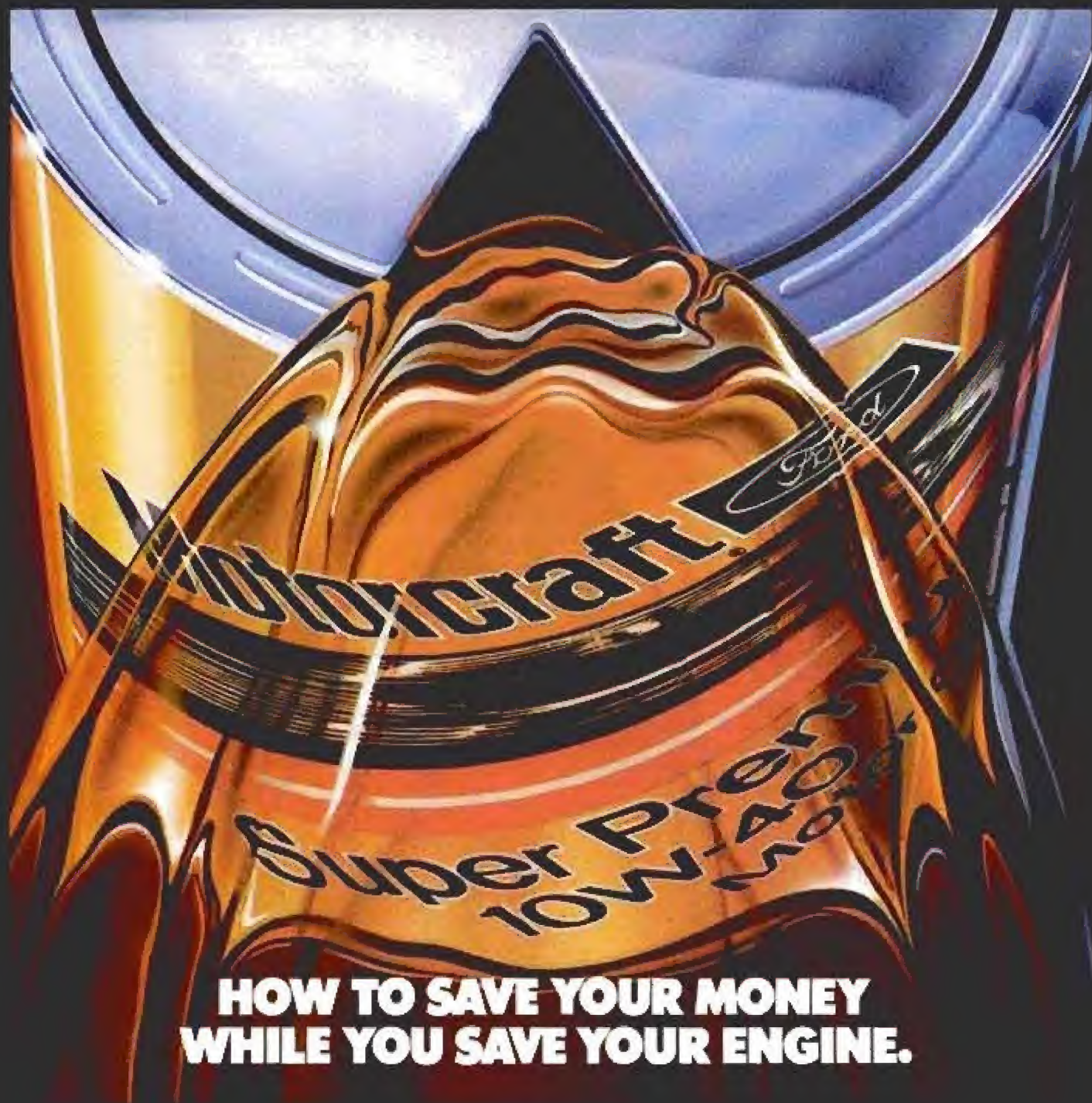
When a new battery has been installed, make sure it is securely held by hold-down clamps. A loose battery will vibrate. A crack in the case or loose terminals may result, and the battery will have to be replaced.

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Ideal temperature-adjusted reading for specific gravity of the electrolyte is 1.270.





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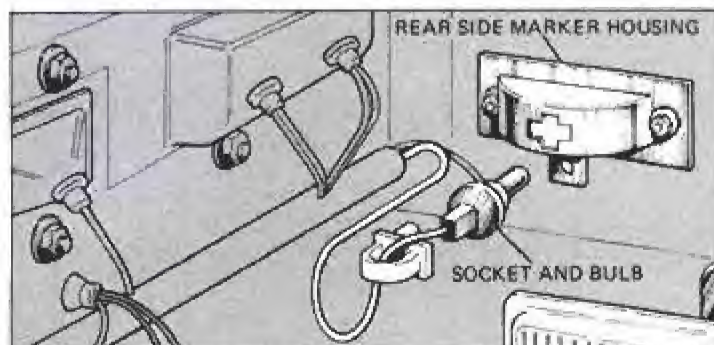
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## 32. BULBS 33. FUSES 34. HEADLIGHTS



Replacing any bulb in your car is a snap. Grab socket (left) and pull it from the housing. In the other case, take off lens and replace bulb.

**B**ulbs are no problem. If a light fails to work, you can conclude that the bulb is burned out. Replacement is a matter of minutes. However, if bulbs aren't to blame or they continue to burn out, the problem may be with the wiring or a fuse.

When an electrical accessory fails to work, such as the air conditioner, heater/air conditioner blower motor, stereo or power-operated seats, the cause can be an electrical or mechanical malfunction. You have a better shot at correcting an electrical problem; overcoming a mechanical failure often requires special tools. Therefore, first check for a bad fuse or wire.

Handling burned-out bulbs, blown fuses and defective switches requires no preparation. But when tracing a bad wire, you're at a disadvantage without a wiring diagram. You can find one in the car service manual or get one by writing to the manufacturer.

Wires in a car are bundled in harnesses. Each wire is color-coded, so you can usually pick out where a wire enters and leaves the harness. The diagram helps you to find the entry and exit points easily, also to trace the wire as it worms through the circuit.

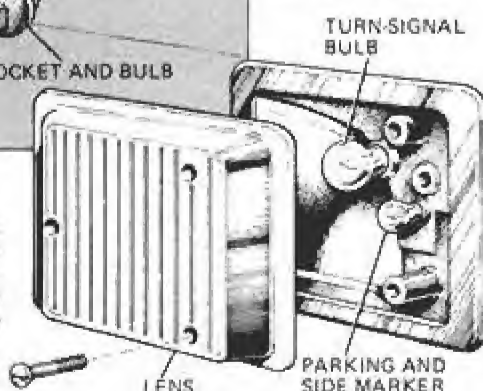
Once a defective wire is found, replacing it entails splitting apart the harness and disconnecting the wire at both terminal points. If the wire passes through a panel, an easy way to replace it is to tape a new wire of adequate length to one end of the old wire. Fish the new wire into place by drawing the old wire through from its other terminal point. Once it is in position and connected, wrap the split harness with electrician's tape.

### Replacing bulbs

Following are methods of replacing bulbs in the most common reflector housings:

**1. Remove the screws and lens.** There is a gasket behind the lens, so be careful not to tear it. Push in and twist the bulb counterclockwise to remove it.

Buy a replacement bulb with a number matching the number on the base of the old bulb. Push the new one into the socket and



twist it clockwise. Install the gasket and lens.

**2. If screws holding the lens to the reflector housing are not visible, approach the bulb from the rear of the reflector housing.** Reach around and feel to see if a bulb holder projects from the housing. If so, push and twist the holder to detach it. Then replace the bulb and reinstall holder.

**3. If there are no visible screws and no bulb holder, remove the reflector housing to reach the bulb.** Turn out two screws that hold the housing in the rear; pull it free from the front. Then pull the lens free of the housing, replace the bulb, lens and housing.

### Replacing headlights

A burned-out headlight is easy to replace:

**1. Remove the trim ring by undoing screws.**

**2. Examine the assembly.** Remove only the screws holding the retaining ring around the lamp. Do not turn the two adjustment screws that aim the lamp or the headlight will be shifted out of adjustment.

**3. Draw the lamp out far enough so you can grasp the socket.** Hold the socket firmly and pull the lamp forward to free it. Caution: Don't tug the lamp without grasping the socket. You may damage the wiring.

**4. Install a new lamp having the same number as the old one.** Reassemble the unit.

### Replacing fuses

When an accessory doesn't work or a bulb that's not burned out won't light, check the circuit fuse. Find the fuse box, under the dash or in the engine compartment.

Fuses are either metal or ceramic links enclosed in a see-through container. A break in the link means a blown fuse. Metal and ceramic fuses are held in clips in the fuse box. Use a fuse puller to remove them.

Some fuses have links embedded in ceramic so you can't tell whether a fuse has blown. Replace such a fuse with a good one to see if the accessory or light is reactivated. Caution: If a new fuse burns out soon after installation, there is a short circuit. Find and repair it before installing another fuse.

### Simple circuit tests

■ Suppose a turn signal doesn't work and bulbs aren't to blame. The cause may be a faulty flasher or a bad circuit. Locate the flasher beneath the dashboard and pull it out of its socket. Have a test wire ready—a piece of 14-gauge wire about 12 inches long and stripped of insulation at the ends. Insert the bare ends into the socket that holds the flasher and try the turn signal. If it works, the flasher is bad. Replace it.

■ Suppose an accessory or light doesn't work, but the fuse and bulbs are okay. Check the switch. Reach behind it, detach the wires. Then touch them together. If the accessory or light works, the switch is bad. Replace it.

■ Use a 12-volt circuit tester to trace a possible wiring defect. Connect the alligator clip to a metal surface (ground) and penetrate wiring insulation with the probe. If the tester light glows, the circuit to that point is okay. If it doesn't glow, examine the circuit for a corroded terminal or connector, or a chafed wire that is shorting out. Wrap chafed wiring with electrician's tape. Clean corroded terminals and connections. If no damage is visible, the wire may be broken under the insulation. It will then have to be replaced.



After a headlight has been replaced, you should be sure to have its aim adjusted.

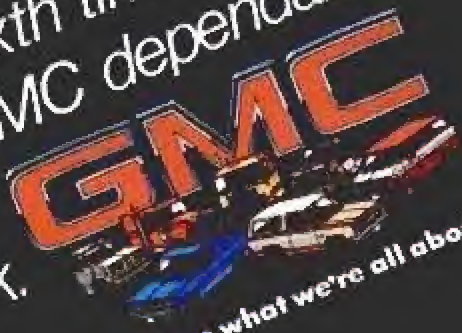




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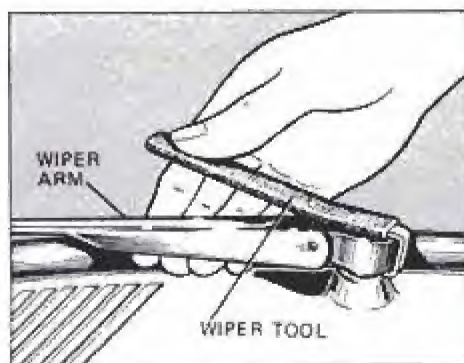
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## 35. WINDSHIELD WIPERS



To remove a wiper, it's best to use the tool which lifts it off the splined shaft.

When windshield wipers go bad, streaks appear on the windshield as the wipers operate, or the rubber blades chatter as they sweep the glass.

There are three main parts of a windshield wiper:

- The rubber blade (squeegee).
- The blade-holding assembly that holds the squeegee.
- The wiper arm to which the blade-holding assembly is attached.

### Replacing rubber blades

When rubber blades deteriorate, they can be replaced without having to replace the entire assembly. Examine old blades. If there is a red tab, press it to disengage the blade from the holding assembly and pull squeegee free.

If there isn't a red tab, squeeze the ends of the metal clip that holds the blade to the holding assembly and slide the squeegee out of the holder. Push the new squeegee into the holder until the clip snaps in place.

### Replacing the blade holder

If the blade-holding assembly is bent out of shape, replace it. You can disconnect it from the windshield-wiper arm in one of several ways, as follows:

1. By pressing a release lever under the connector, so the assembly can be pulled free of the arm.
2. By pressing a release lever alongside the connector, so the assembly can be drawn from the arm.
3. By depressing a spring release with a screwdriver to disengage the assembly from the arm.
4. By pressing a release lever that allows you to disengage the lock arm of the assembly and the link on the arm to which it locks.
5. By pulling a slide lock on the arm away from the hook on assembly to release it.

Wiper arms of many cars are disengaged from the windshield-wiper motor by placing a wedge under the pivot and prying the arm off. They, too, should be replaced if they are bent out of shape.

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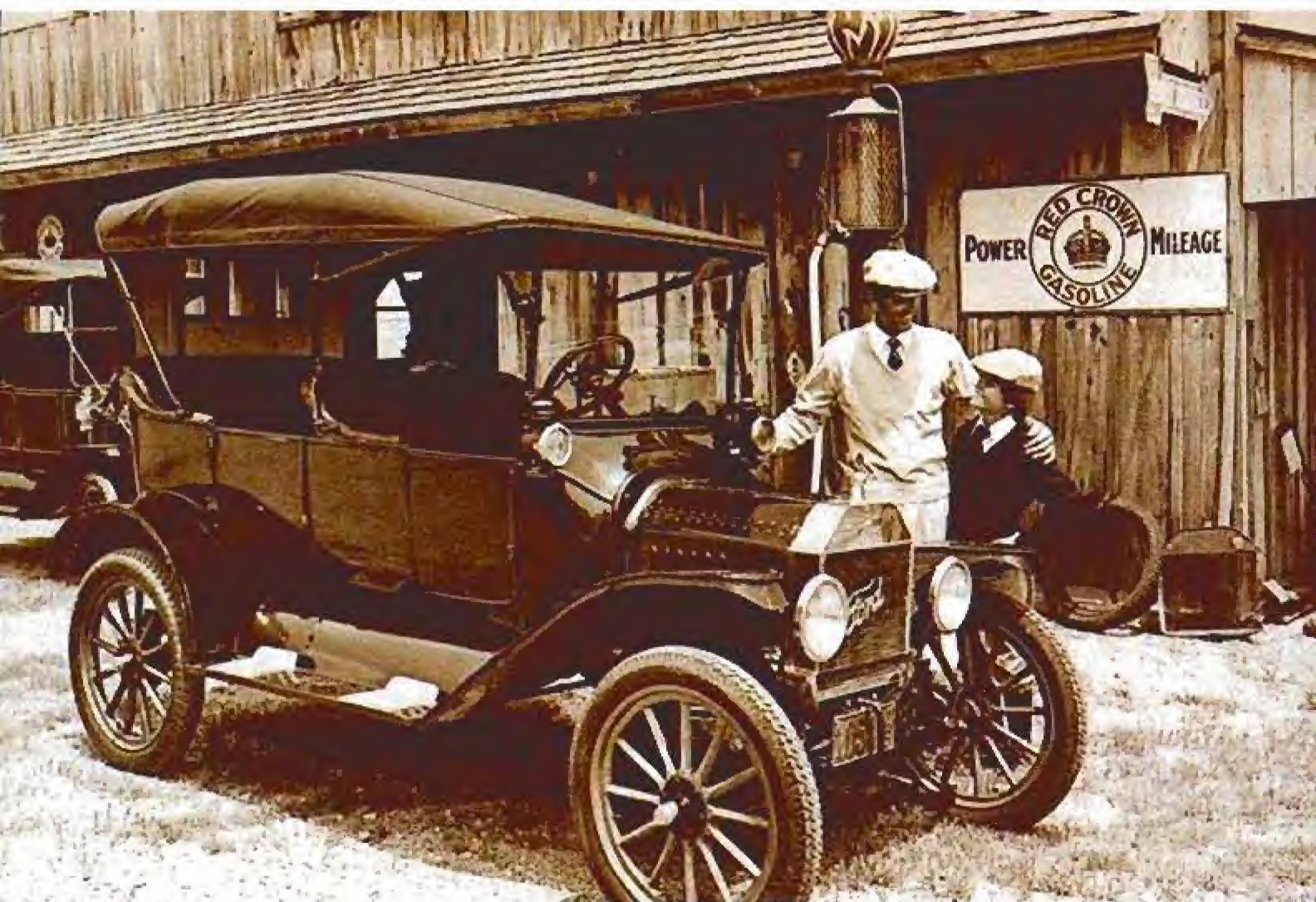
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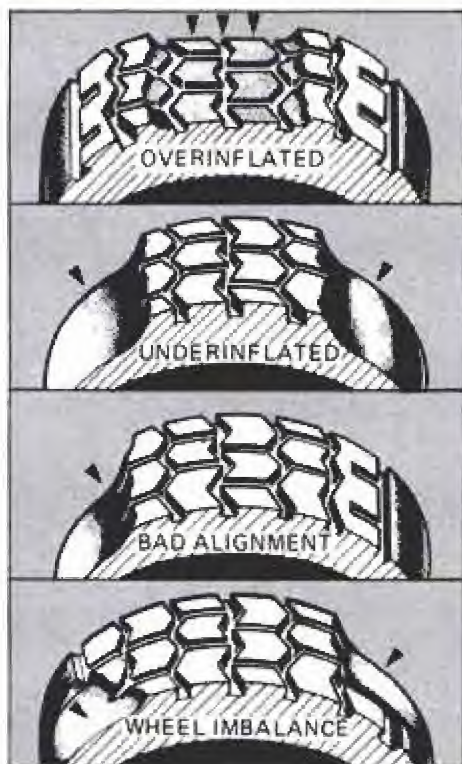


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## 36. TIRES



Any of these problems can cause abnormal tire wear, severely reducing tread life.

Eventually, tires have to be replaced. However, improper wear due to mechanical malfunctions prematurely robs tires of their usefulness and crimps an owner's budget.

A tire worn down normally is at the end of its safe and legal life when a smooth, continuous strip appears across the footprint, from one side to the other. When these smooth tread bars show up in two or more places over the tire surface, buy replacements.

Tread bars may not appear on radials, but you'll be able to tell when tires are approaching a hazardous state by measuring with a tread-depth indicator. If depth is below the legal  $\frac{1}{16}$ -inch mark, replace tires.

If tires show signs of abnormal wear, try to spot trouble before it can take its toll by periodically inspecting tires for:

1. **Tread wear more pronounced at both outer edges than in the center**—caused by riding on underinflated tires. Inflate the tires to manufacturer's recommendation.
2. **Tread wear more pronounced in the center than on outer edges**—caused by riding on overinflated tires.
3. **Tread unevenly worn at one or more spots**—normally caused by an out-of-balance tire-wheel-brake assembly.
4. **Tread feathered along the edges**—signifying faulty wheel alignment.
5. **Tread worn along one edge**—also indicating faulty wheel alignment.
6. **Tread scalloped at even intervals**—signifying a worn or misadjusted suspension or steering component. **FM**

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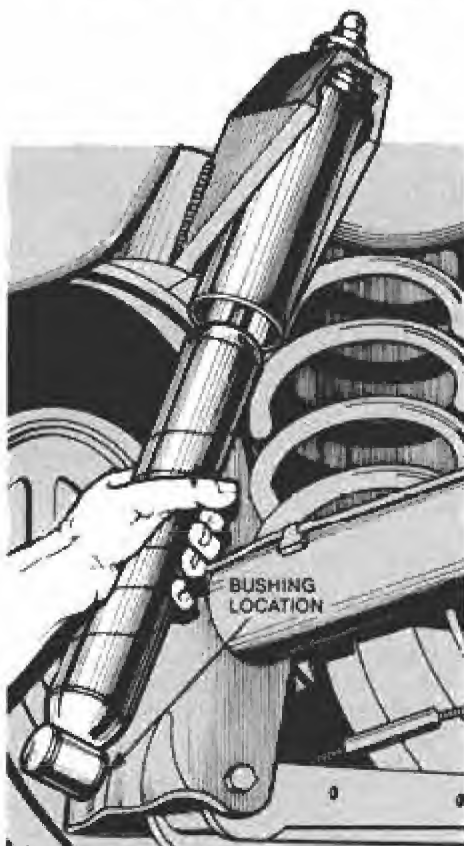
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# 37. SHOCK ABSORBERS



When installing shocks, make sure all rubber bushings and grommets are in place.

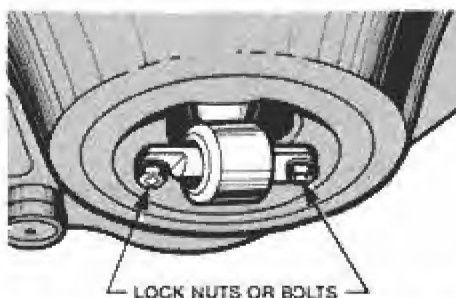
**B**ad shock absorbers are the cause of the following problems:

- The car bounces or bottoms over bumps.
  - The front of the car noses down when making a quick stop.
  - Noise is heard from beneath the car when it's going over bumps.
  - Abnormal tire wear develops.
- You may be able to confirm the existence of worn shocks by getting under the car and examining them for the following conditions:
- Fluid leaking down a shock cylinder.
  - Looseness. Grasp each shock and try moving it. It should permit only barely perceptible movement.
  - Dents in the cylinder.

If suspected shocks don't show any of these conditions, push the car up and down at each corner. In turn, causing the car to bounce. Release the car on a downstroke. It should come to almost an immediate stop. If the car continues bouncing, remove the shock at that corner of the car for more testing and, if necessary, replacement.

## Replacing shock absorbers

**Note:** When one shock has to be replaced, the shock on the other side of the car should also be replaced to assure balance at that end of the car. In other words, always replace front



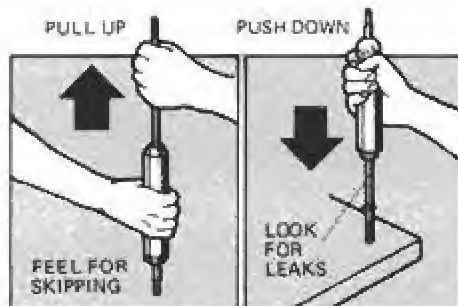
**Torque down all locknuts or bolts to the manufacturer's recommendation. Use all lock washers that come with new shocks.**

shocks as a pair and rear shocks as a pair.

To replace shock absorbers, do this:

1. **Raise the car and place it on strong supports.** Don't use a bumper jack. A serious accident may result.
2. **Soak shock bottom mounting bolts with penetrating oil.** If top mounting bolts can be reached from beneath the car, also soak them with oil. Let oil penetrate.
3. **Unbolt the lower end of the shock.** Then, if upper-end bolts are reached from below, free upper end. Remove shock.
4. **If the upper end of the front shock can't be freed from below, free it from inside the engine compartment.** Free a rear shock from inside trunk.
5. **Test the shock by moving it in and out by hand after it is removed.** Then move a new shock in and out by hand. The object is to compare the resistance offered by the old shock to that of the new. If the old shock doesn't offer strong resistance as you move it in and out, discard it. If resistance is good, you can put the old shock back on and store the new shock for future use.

**Note:** When replacing rear shock absorbers, lift the rear axle with a hydraulic jack or support to take pressure off the shock so it can be disconnected.



**Test shocks both ways. Push in and check for oil leakage, pull and check for skipping.**

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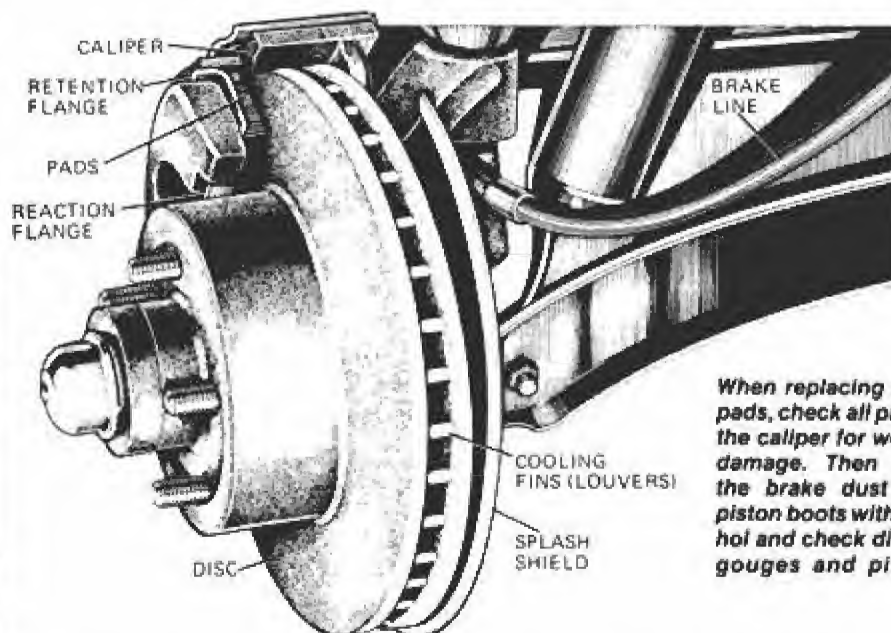
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## 38. BRAKE PADS



*When replacing brake pads, check all parts in the caliper for wear or damage. Then clean the brake dust from piston boots with alcohol and check disc for gouges and pitting.*

**T**he following conditions indicate that brake pads may be worn, glazed or contaminated by grease or brake fluid:

- Brake pedal feels hard.
- Braking causes car to pull to one side.
- Brakes make noise when applied.
- Brakes grab.

Two dangers arise if you don't replace defective pads: (1) Faulty braking may lead to an accident; (2) the brake rotor can be damaged, which greatly increases the cost of repair.

Check to see if pads are worn or contaminated by lifting the car and removing a wheel-and-tire assembly to uncover a caliper and rotor. Look at the pads through inspection slots in the caliper. If a pad is worn to within  $\frac{1}{8}$  in. of its metal backing (shoe), if there's more than a  $\frac{1}{8}$ -in. taper from one end of a pad to the other, or if there are dark spots on a pad that indicate contamination by grease or brake fluid, replace pads. Inspect pads on the other wheel in the same way.

*Note:* If you have to replace pads on one side of the car, maintain braking equalization by replacing pads on the other side, even though those pads may not be worn as much; Brake pads on the same end of the car, front or rear, should be replaced as units.

The actual procedure involved in replacing disc-brake pads depends on the particular disc-brake assembly in the car. Steps outlined here apply to the single-piston, sliding-caliper front assembly used in many late-model Ford Motor Co. cars, including Thunderbird and XR-7, Fairmont and Zephyr, Granada and Cougar, and Mustang and Capri. If you don't have specific instructions, use this procedure as a guide.

**1. Remove and discard brake fluid from the primary (large) reservoir of the master cylinder.** Use a clean syringe.

**2. Remove the wheel-and-tire assembly.**

**3. Remove the caliper locating pins and lift the caliper off the rotor.** Using a wire hanger fashioned into a hook, suspend the caliper from a convenient place on the chassis.

**4. Remove and discard outer and inner pads.** Also remove and discard the plastic sleeves inside the caliper locating-pin insulators and the insulators themselves. Replace these with new parts.

**5. Begin assembly by placing a  $\frac{3}{4}$  x 1 x 2 $\frac{1}{2}$ -in. block of wood against the piston.** Secure this with a 4-in. C-clamp and drive the piston into its bore. Remove clamp and block. The piston will stay put.

**6. Install new inner and outer pads in the caliper, observing the following precautions:**

- Be sure the antirattle clip and insulator are attached to the inner lining before the lining is put into the caliper.
- Make sure the two torque buttons of the outer shoe are seated securely in the two holes in the outer part of the caliper. If they aren't seated, loss of braking may occur.
- Be sure that inner and outer shoes are placed correctly on the caliper—either on the inside so it contacts the back surface of the rotor, or on the outside so it contacts the front surface of the rotor. The inner shoe has the antirattle spring; the outer shoe the torque buttons.

**7. Reposition the caliper on the rotor and install the locating pins.**

**8. Install wheel-and-tire assembly.** Refill master cylinder with fresh brake fluid. Bleed the brake system.

**9. Pump the brake pedal several times so pads seat themselves.** Then road-test the car. **PM**





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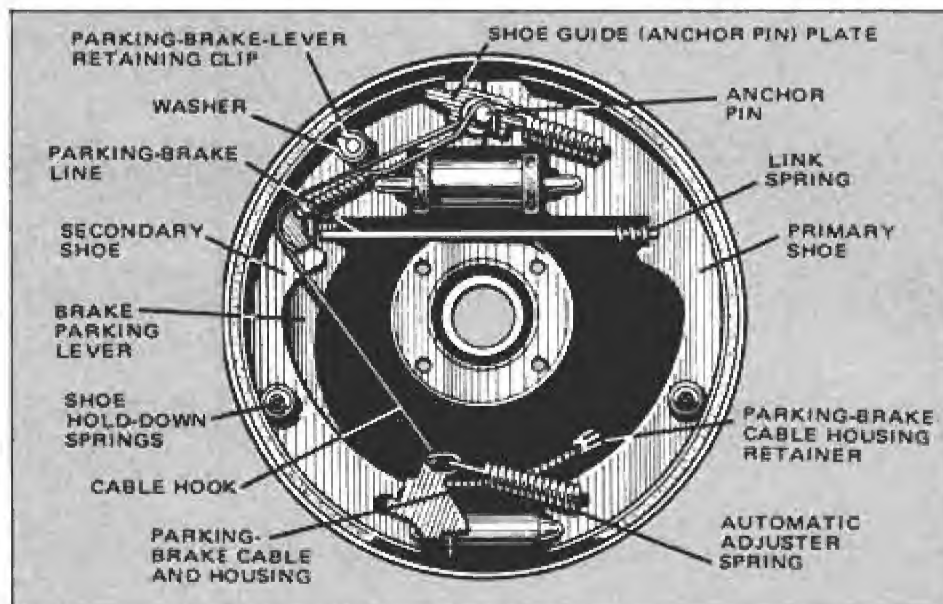
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## 39. BRAKE LININGS



When you reassemble drum brakes after linings have been installed, make sure return springs and retaining clips are firmly secured. Special brake tools make job easier.

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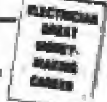
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The following conditions indicate that linings of drum brakes are worn, glazed or contaminated by grease or brake fluid:

- Brake pedal feels hard.
- Braking causes car to pull to one side.
- Brakes make noise when applied.
- Brakes grab.
- Brake pedal stays low after adjusting.

When you get one of these conditions, remove brake drums to inspect linings. If any lining is glazed or contaminated by grease or brake fluid, replace both linings of the particular brake assembly and both linings of the other wheel on the same axle. This will prevent uneven braking action.

Linings are bonded or riveted to metal plates called shoes. Replace shoes if bonded linings measure  $\frac{1}{16}$  in. or less at the thinnest point. If riveted linings are used, replace them if the lining is less than  $\frac{1}{16}$  in. from rivet-head tops.

**Note:** This is based on GM models with front disc brakes and rear drum brakes with self-adjusting shoes. Other models are similar.

1. **Release the parking brake.**
2. **Remove the brake drum.** You may have to go back off the self-adjusting brake-shoe mechanism to remove the drum. Insert a tool through the adjusting hole in the drum or backing plate and rotate the adjusting screw to draw shoes away from the drum.
3. **Install a cylinder clamp to restrain the wheel cylinder.**
4. **Unhook primary and secondary shoe-return springs using pliers.** The primary shoe (shorter of the two) is that nearest the front of the car.
5. **Remove retaining springs that hold shoes to the brake backing plate.**

6. **Lift up on the self-adjusting mechanism,** unhook the actuating link from the anchor pin and remove it.

7. **Spread shoes and unhook them** from the wheel cylinder.

8. **Remove the parking-brake strut and spring,** and disconnect the parking-brake cable from the parking-brake lever.

9. **Remove the shoes.**

10. **Apply brake lubricant to fulcrum end of the parking-brake lever.** Attach lever to the new secondary shoe. Be sure it moves freely. Hook the self-adjusting screw spring to new primary and secondary shoes. Position the self-adjusting screw, but be sure the spring doesn't touch the star wheel on that screw.

11. **Apply thin coat of brake lubricant to shoe contact surfaces of the brake backing plate.** Place the new shoes on the backing plate; engage them to links of the wheel cylinder.

12. **Connect parking-brake cable to the parking-brake lever.** Install the parking-brake strut and spring between the lever and primary shoe.

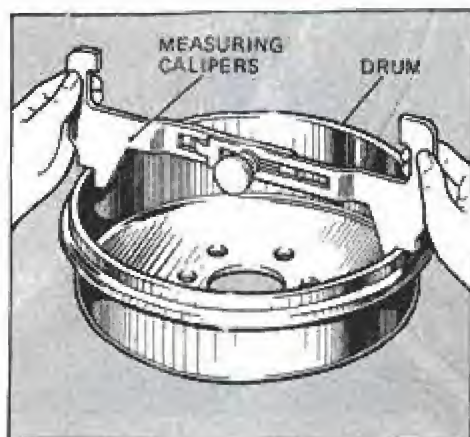
13. **Install actuator,** actuator return spring and actuating link, followed by shoe-retaining and shoe-return springs. If any part is damaged, replace it.

14. **Adjust the linings.** Measure inner diameter of the brake drum with the inside caliper part of a brake-measuring gauge. Then place the outside caliper part of the gauge across the linings and adjust until linings touch the outside calipers.

15. **Install the brake drum. Bleed brakes.**



## 40. BRAKE DRUMS



After the drums have been cut and trued, their inner diameters must be measured.

Scored or out-of-round drums of a conventional brake system will give you the same problems as those caused by damaged rotors of a disc-brake system. These problems are:

- Roughness (chatter) and/or squeaking or groaning when brakes are applied.
- Uneven braking action from front to rear or from side to side.
- Harder force on the pedal is needed to bring the car to a stop.

### Removing drums

If you suspect that your brake drums are the source of a braking problem, remove each tire, wheel and brake drum as an assembly, as follows, so that you can inspect the drums:

1. Remove the wheel cover.
2. Pry off the grease cup.
3. Remove and discard the cotter pin.
4. Take off the castellated nut and undo the wheel nut and washer.
5. Clean the spindle and then pop out the outer wheel bearing by pulling the wheel toward you.
6. Remove the tire, wheel and brake drum.

### Inspecting drums

Lay the assembly down with the drum facing up. Clean the inner surface of the drum with a solvent, such as lacquer thinner. Then, using a flashlight, examine the inner surface carefully for cracks, score marks and grooves.

You may be able to polish out surface defects with a fine emery cloth, but replace the drum if the score marks or grooves are penetrating deeply into the metal.

If a drum is cracked, replace it. Don't try to have the crack welded. It won't hold, and you'll be putting safety on the line. The drum could crack apart during a panic stop.

By inspecting the brake linings, you'll be able to tell if the drum surface is out of round or

tapered. Linings that show significant wear at one or both ends (that is, at the toe or heel), but little wear in the center, indicate an out-of-round brake drum. Linings that show uneven wear from one side to the other signify that the drum is tapered. The out-of-round or tapered condition can be verified with a gauge when you take the drum to a brake shop for turning.

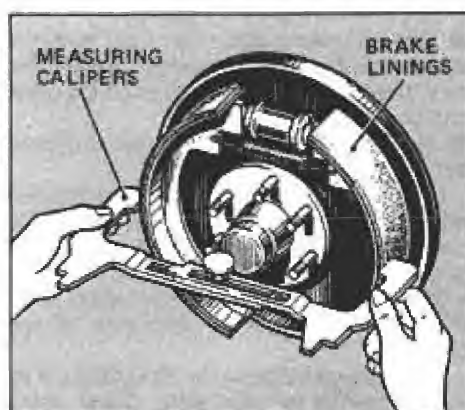
Turning is done on a drum-turning lathe. After the drum surface is evened, the brake specialist should check the drum with a micrometer to make sure the amount of metal remaining meets the standard established by the car manufacturer.

Reinstall the tire-wheel-brake drum assembly by placing the assembly back on the car, installing the outer wheel bearing and associated parts and adjusting the wheel bearing (see Part 47).

### Adjusting a wheel bearing

When installing a bearing, you should be extremely careful that you don't overtighten the castellated nut which holds the entire assembly in place.

The nut should be tightened just to the point



Drum inner diameter and lining diameter must meet the factory specs for mounting.

where you feel resistance when trying to turn the wheel hub. Once you feel a resistance in the nut, back off on the nut until the wheel hub will spin freely but doesn't wobble on the bearing.

The way to avoid a hit-or-miss tightening of the nut is to identify the position of the nut with a chalk mark and a corresponding chalk mark on the hub.

When you install the nut again, line up the two chalk marks and the setting should be correct.

Either an overtightened nut or one that's too loose will cause wheel-bearing wear, shaking in the tire, loss of grease and, ultimately, be responsible for a very expensive repair job.

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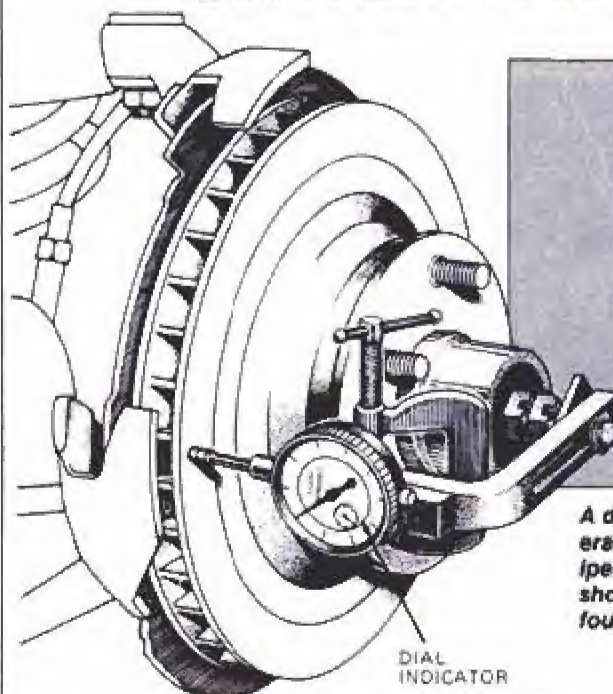


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## 41. BRAKE ROTORS



A dial indicator is used to check lateral runout of a disc face; vernier calipers check the disc width. You should take the caliper reading at four places around the disc.

**D**isc-brake rotors that are scored, out of parallel or exhibiting excessive runout demonstrate the following conditions:

- Roughness (chatter) and/or squeaking or groaning when brakes are applied.
- Uneven braking action from front to rear or side to side (brakes on one end or side will feel as if they are holding better than on the other end or side).
- Harder force on the pedal is needed to bring the car to a stop.

In addition to checking rotors for obvious physical damage, especially score lines and rust, test them for lateral runout and parallelism. Lateral runout refers to movement of the rotor from side to side. Parallelism refers to the thickness variation of the rotor over its surface.

A dial gauge calibrated in 10/1,000ths of an inch is needed for these tests. Check lateral runout as follows:

1. Tighten wheel bearings, so there is no bearing play.
2. Attach the dial gauge so the point of the gauge stylus touches the face of the rotor about 1 in. from the edge of the rotor.
3. Set the dial at zero and rotate the rotor by hand through one complete revolution.
4. Lateral runout, as recorded by the gauge, should not exceed maker's specification. If you don't know it, consider .004 in. as the maximum reading the gauge should record.

To check parallelism, measure the thickness of the rotor at four or more points around its circumference. Take all measurements at the same distance from the edge of the rotor. They should vary no more than .0005 in.

A rotor that demonstrates slight lateral

runout or thickness variation, or light scoring, may be machined to remove defects as long as not too much metal is removed. The shop doing the machining will have manufacturer specifications for minimum thicknesses after refinishing, which differ from rotor to rotor. If they are exceeded, install a new rotor.

### Replacing the rotor

To remove the rotor for machining or replacing, proceed as follows:

1. Draw a chalk mark from the wheel across the hub. This is made so wheel balance will be maintained when the wheel is reinstalled by lining up the chalk mark on the wheel with that on the hub.
2. Remove the caliper.
3. Remove the cotter pin that holds the wheel nut. Then remove the nut.
4. Reach in the hub and remove the outer wheel bearing.
5. Reattach the wheel nut to its place on the spindle and draw the rotor toward you. This nut will push the inner wheel bearing and grease retainer from their seat in the rotor. Remove all parts, including rotor.
6. To install a rotor after it's been machined (or to install a new rotor), place the inner wheel bearing and a new grease retainer in the rotor. Use a wheel-bearing seating tool or carefully tap them into place with a length of dowel. Note: When you remove wheel bearings from the rotor, inspect them for damage. If they are in good shape, clean, lubricate with wheel-bearing grease and reuse them. Do not reuse grease retainers.
7. Install the rotor, then the outer wheel bearing, washer and wheel nut. Adjust wheel bearings (see Part 47).



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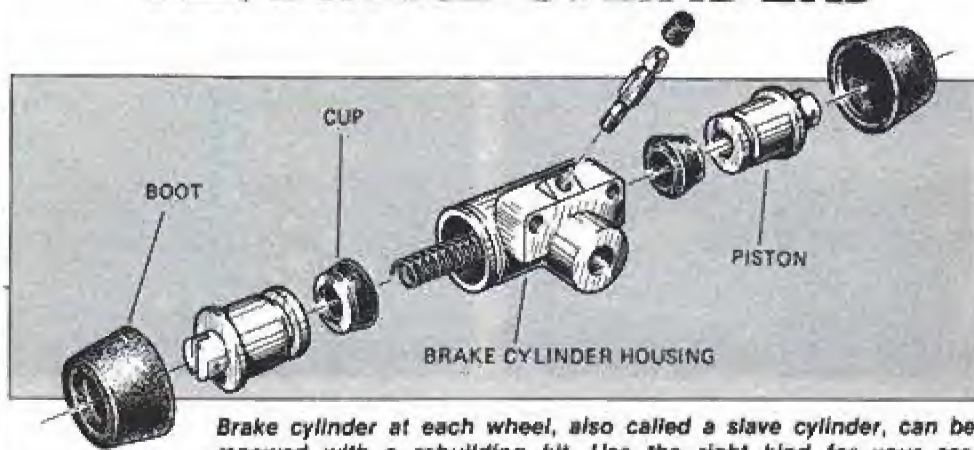


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## 1981 CAR CARE GUIDE

# 42. BRAKE CYLINDERS



Brake cylinder at each wheel, also called a slave cylinder, can be renewed with a rebuilding kit. Use the right kind for your car.

**A**t each wheel in a drum-brake system, there is a wheel cylinder. When brakes are applied, brake fluid exerts its force against wheel-cylinder parts. Parts of the cylinder, in turn, transfer energy to force linings into contact with brake drums. When brakes are released, hydraulic pressure is relieved. Wheel-cylinder parts retract, and so do brake linings.

Other than the remote possibility that wrong-size wheel cylinders have been installed, the only problems a wheel cylinder can suffer are worn or sticking parts. When parts wear, wheel cylinders permit brake fluid to leak. A fluid leak usually results in greater braking effort being needed to stop the car, and a low brake pedal. If leaking fluid contaminates brake linings, then conditions outlined in Part 39 will also occur.

If wheel cylinders are sticking (actually, it's the pistons that stick), one or more of the following will happen:

- The brake pedal may fall away under pressure.
- It may take greater effort on your part to stop the car.
- Brakes may be slow to respond and slow to release.
- Brakes may drag.
- There may be uneven braking action from one side of the car to the other.

To determine if wheel cylinders are leaking or sticking, remove the tire-wheel-brake drum assembly. Examine linings and brake backing plate for signs of brake fluid. Then draw each rubber cover off the wheel cylinder to see if fluid drips out. This indicates that wheel-cylinder parts are worn.

If fluid is leaking from the cylinder, overhaul the cylinder, if possible, or install a new one.

### Removing and overhauling a wheel cylinder

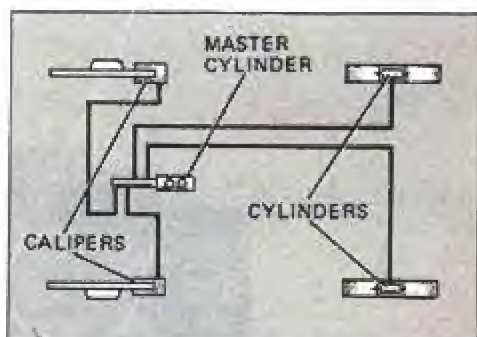
It's usually necessary to remove brake shoes in order to remove a wheel cylinder from the brake backing plate (see Part 39). Then undo the retaining bolts holding the wheel cylinder and remove the part from the brake backing plate.

**Important:** When you disconnect the brake line that feeds hydraulic fluid to the wheel cylinder, be sure to tape the end of the line to keep out dirt.

If any dirt contaminates the brake fluid, you will have to drain the hydraulic system and fill it with new fluid.

To disassemble a wheel cylinder, do the following:

1. **Remove and discard rubber covers.**
2. **Press out cylinder pistons, cups and the spring expander.** Discard parts duplicated in the wheel-cylinder overhaul kit. Check with your auto-parts and accessories dealer for the correct kit to buy. Generally, a kit contains new rubber covers, cups and a spring expander.
3. **Wash the cylinder in clean brake fluid or alcohol** and inspect the cylinder bore for scratches and corrosion. If a cylinder is scratched or corroded, do not hone it unless the car manufacturer specifically allows honing.
4. **If the cylinder bore is only stained, insert crocus cloth and turn the cylinder on the cloth.** Do not press against the bore with the crocus cloth and do not slide the crocus cloth lengthwise across the bore. Wash the cylinder in brake fluid or alcohol. Then dip parts in clean brake fluid and install them in the cylinder.

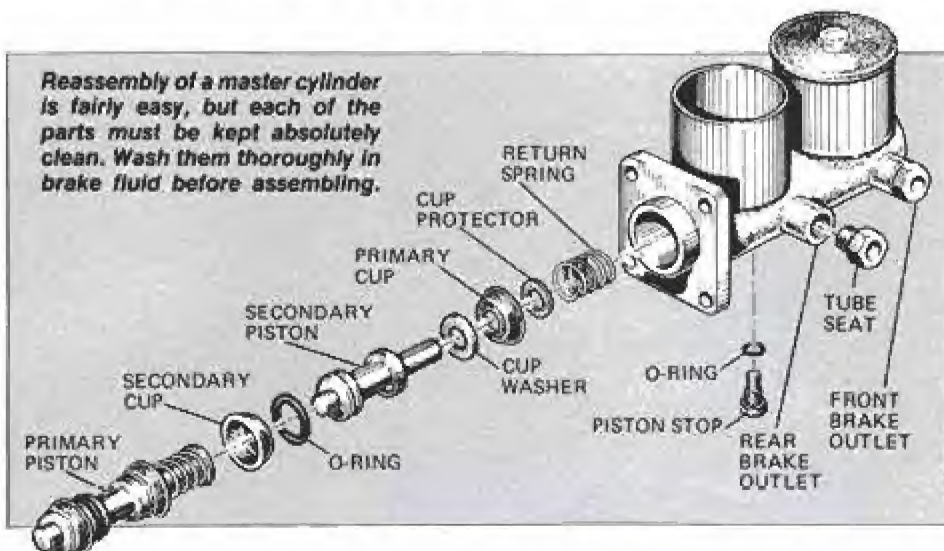


When bleeding a brake system, start at the wheel farthest from the master cylinder.



# 43. MASTER CYLINDER

Reassembly of a master cylinder is fairly easy, but each of the parts must be kept absolutely clean. Wash them thoroughly in brake fluid before assembling.



The master cylinder is the main reservoir and dispensing unit for brake fluid. In addition to holding the fluid, the master cylinder forces fluid through the brake lines to wheel cylinders of the drum-brake units, and to pistons that cause the pads to engage the rotors in a disc-brake system.

A leaking master cylinder will result in a fading brake pedal. In addition, if your car is equipped with a brake warning light on the dash, the light will glow when the brake is applied.

## Locating a leak

You can detect a leak without removing the master cylinder by keeping your eye on the brake-fluid level. If the level is low, fill the master cylinder with fluid. Then have someone maintain pressure on the brake pedal as you inspect the brake system (lines, hoses, all connections, wheel cylinders) for leaks. If there is no visible leak at these points, the master cylinder is probably leaking internally.

Where does the fluid go? In a manual (non-power) braking system, fluid may be leaking into the master-cylinder boot between the cylinder and brake pedal. You can often verify this by prying the boot away from the cylinder to see if brake fluid leaks out.

If the master cylinder is connected to a power booster, the fluid may be leaking into the power booster. From there, the fluid could be drawn by vacuum through the vacuum hose into the engine. You may be able to verify this by removing the vacuum hose and inserting a pipe cleaner or screwdriver into it. Fluid on the pipe cleaner or screwdriver when it's withdrawn is an indication that the master cylinder is leaking.

Note: Replace a bad master cylinder. Do not overhaul it.

## Replacing a master cylinder

To remove a master cylinder, proceed as follows:

1. **Disconnect the brake lines from the cylinder.** Tape ends of the brake lines to keep dirt from contaminating the brake fluid.
2. **Disconnect the master-cylinder pushrod from the brake-pedal rod if the car has a manual brake.**
3. **Remove the nuts that hold the master cylinder to the firewall** or to the brake power booster.
4. **Withdraw the master cylinder** and any gasket you may find.
5. **To install a new cylinder, do the reverse.** Be sure that the nuts and fittings are connected tightly. Fill the cylinder with a high-quality brake fluid recommended by your auto-parts and accessories dealer. Then bleed air out of the system.

## Bleeding the system

Each manufacturer has its own method for bleeding the brake system. To be safe, consult your owner's manual or a shop manual for the method and sequence of bleeding the brakes.

Generally, however, you can be pretty safe by beginning the bleeding procedure with the wheel which is furthest away from the master cylinder. In most cases, that is the right rear wheel.

1. **Fill the master cylinder to the recommended maximum level.**
  2. **Unscrew the bleed screw half a turn and attach a length of hose.** Immerse the free end of the hose into a clean receptacle half filled with clean brake fluid.
  3. **Have someone in the car press on the brake pedal.** Fluid and air will flow out of the bleed screw.
  4. **Tighten the bleed screw before your assistant releases pressure from the brake pedal.** This prevents air from re-entering the system.
- Keep the fluid level in the master cylinder at the recommended maximum and repeat the above procedure for each wheel. **PM**

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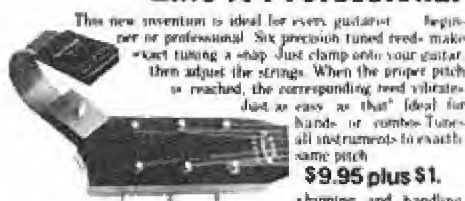
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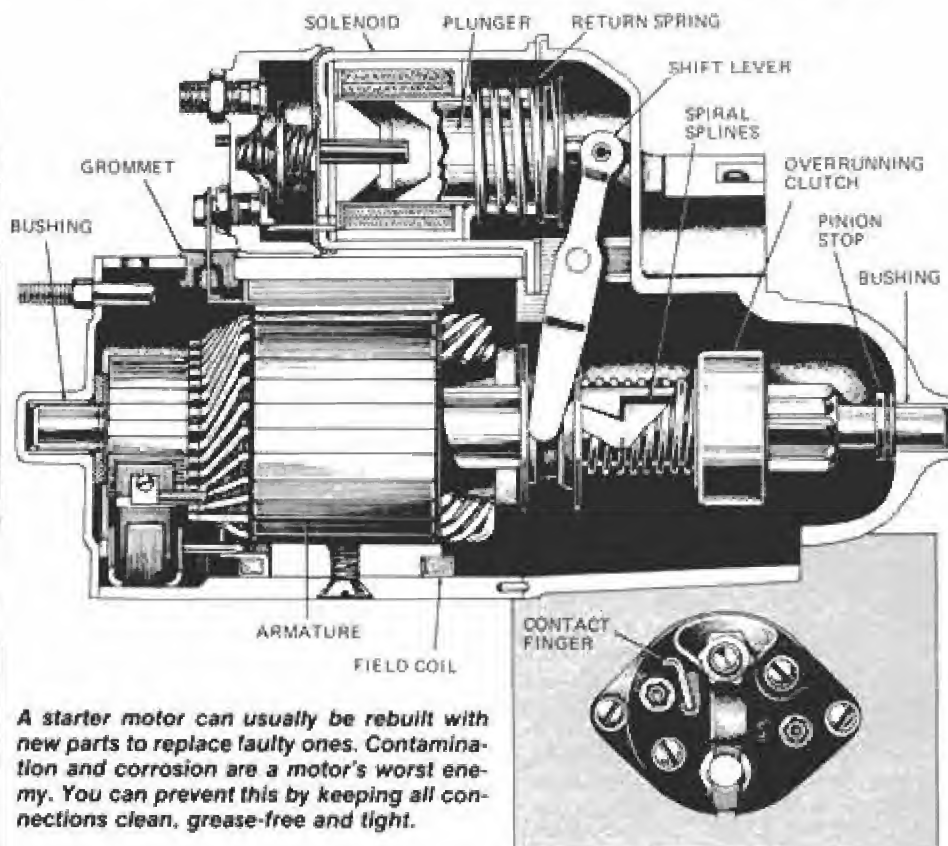
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# 1981 CAR CARE GUIDE

## 44. STARTER MOTOR



A starter motor can usually be rebuilt with new parts to replace faulty ones. Contamination and corrosion are a motor's worst enemy. You can prevent this by keeping all connections clean, grease-free and tight.

If your starter motor is malfunctioning, one of the following two conditions will probably exist:

- There will be no cranking action
- Cranking speed will be very low.

There are, however, other components that cause these problems. They are the battery, battery cables, starter solenoid and starter relay.

Determine if the starter motor is to blame for the problem by testing voltage and amperage. If it fails to meet car manufacturer specifications, remove the starter motor from the engine for overhauling or replacing.

### Replacing the starter motor

Remove the starter motor as follows:

**1. Disconnect the negative battery cable from its post.**

**2. Jack and support the vehicle.** In most cases, the starter motor is removed from under the car.

**3. Disconnect cables attached to the starter motor.** There is more than one cable, so determine to which terminal each cable is attached and devise a marking system, so you will be able to reattach cables to their correct terminals.

**4. Remove the bracket with the motor attached to it if the motor is mounted on a support bracket.** If there is no bracket, simply remove the starter motor from the engine.

Note: In some cases, you may find shims beneath bolts or under a support bracket. These are placed there to assure that starter-motor position is maintained. Make a note of where shims are placed and how many there are. Save shims and reuse them when you reinstall the starter.

If the starter motor is attached to a mounting bracket (or brackets), detach the bracket after the starter has been removed from the car. When you're reinstalling the new or rebuilt starter, reattach the bracket(s) securely.

**5. Hold the starter against the engine.** Install shims if you should need them and insert mounting bolts. Tighten bolts securely.

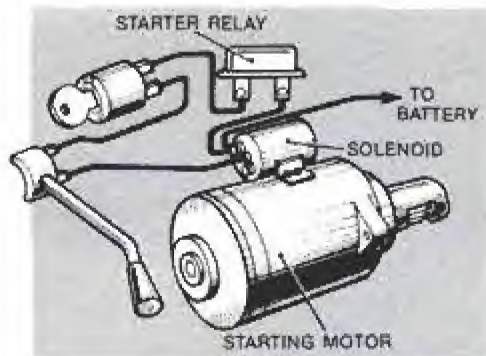
Some cars have starter motors which are covered with a large rubber boot. This boot prevents road splash and other foreign matter from getting to the starter and causing a premature failure. Boots, however, can be a problem in themselves because they can trap water if they're ripped, and prevent it from draining away from the starter.

A good precaution would be to inspect the rubber boot regularly to make sure that it is intact. The boot should also be removed during the inspection and cleaned out.

While inspecting the boot, also look for corrosion and rust on the starter motor and starter-solenoid contacts and terminals. If they show signs of corrosion, clean them with emery cloth and treat with a rust-inhibiting lubricant. **PM**



## 45. STARTER RELAY



Faulty or broken contact in any component shown above prevents starter operation.

When a starter solenoid or starter relay fails, one of the two things listed below will happen:

- The starter motor won't operate.
- The starter motor will click, but it won't turn.

You can get an idea of whether an externally mounted starter solenoid is operating properly by connecting a jumper wire between the BAT and "S" terminals of the solenoid. The BAT terminal has the positive battery cable attached to it. The "S" terminal, usually marked S, is connected by cable to the ignition switch.

Turn the ignition on. If the starter motor operates, the solenoid is okay. The trouble is being caused by the ignition switch, neutral-start switch or wires and connections between the two.

If the starter motor doesn't operate, the trouble is with the starter solenoid or motor. Remove the motor to replace the faulty component.

### Working on starter relays

To test the starter relay in most Ford Motor Co. cars, set the transmission in PARK or NEUTRAL and engage the parking brake. Connect one end of a battery jumper cable to the relay BAT terminal (the one connected by cable to the starter).

Crank the engine. If the starter motor works, the relay is defective. Replace it by disengaging cables and unbolting the component.

To test the starter relay of most Chrysler Corp. models, set the transmission in PARK or NEUTRAL and engage the parking brake. Connect a jumper wire between the BAT and solenoid terminals of the relay.

In a manual-transmission car, have someone depress the clutch pedal. Crank the engine. If the starter motor functions, the relay is okay. The trouble is likely in the neutral-safety switch. If the engine doesn't crank, the relay may be defective, or the trouble may also be with the solenoid inside the starter motor. Replace the relay first by removing wires and unbolting the part. If this doesn't solve the problem, remove the starter motor from the car for overhaul or replacement.

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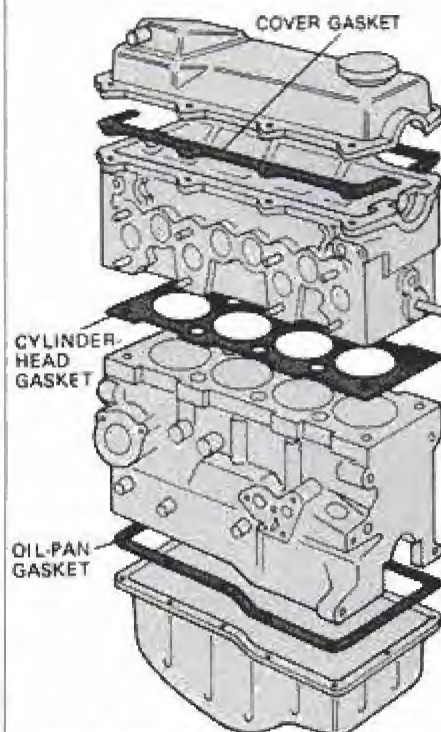
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1981  
**CAR CARE  
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## 46. ENGINE GASKETS



**Gaskets differ both in materials and construction. Use correct type and right sealer.**

**T**he gaskets in your car that most commonly fail are those for the valve covers, oilpan and rear-end differential. The procedure below illustrates how to replace a valve-cover gasket. Use it as a guide to replace the other two.

**1. Remove the carburetor air cleaner.**

**2. Disconnect and identify all hoses and wires that will impede the removal of the rocker-arm cover.** Be sure to pull the PCV valve from its seat in the cover.

**3. Remove bolts holding the cover to the cylinder head.** Lift off the cover.

*Important:* If the cover doesn't budge, and you're sure all bolts have been undone, strike the front end of the rocker-arm cover with the palm of your hand or a rubber mallet. Do not pry under the cover with a tool. You may accidentally gouge the metal.

**4. Clean the surface of the rocker-arm cover and cylinder head with a degreasing agent.**

**5. Apply a 1/4-in. bead of RTV (room temperature vulcanizing) sealer on the cylinder-head surface that mates with the rocker-cover sealing surface.** Avoid clogging bolt holes with sealer.

**6. Install the rocker cover.** Attach bolts until they are finger-tight while sealer is still wet.

**7. Tighten bolts snugly, but do not overtighten.** Tighten them in a crisscross pattern.

**PM**

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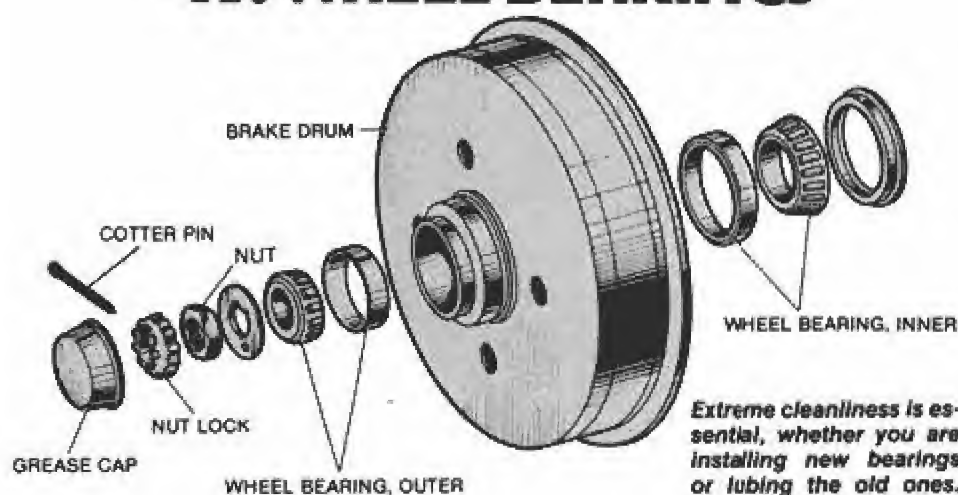
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# 47. WHEEL BEARINGS



*Extreme cleanliness is essential, whether you are installing new bearings or lubing the old ones.*

**W**heel bearings discussed in this section are those on the wheels of nondriven axles—that is, the front wheels of cars with conventional rear differentials and the rear wheels of cars with front-wheel drive. Bearings in these wheels don't receive constant lubrication and are more likely to fail. Bearings in the other wheels are constantly being splattered with lubricant as rear-differential or transaxle gears turn.

A bad wheel bearing can cause one or more of the following problems:

- The car pulls to one side.
- The car wanders from side to side.
- A tire (or tires) wears unevenly (tire tread may scallop).
- The steering wheel shimmies.
- Steering is loose.
- Noise comes from the affected wheel.

## Servicing wheel bearings

**Note:** The procedure described here assumes a car with a rear differential and front disc brakes, with wheel bearings in the rotors. The procedure is basically the same for bearings of wheels having drum brakes. However, if you're working on a drum-brake setup, take off the tire, wheel and brake drum as a single unit.

To service the wheel bearings, proceed as follows:

1. **Remove the wheel and tire.**
2. **Take the caliper off the rotor.** Using a wire hanger fashioned into a hook, hang the caliper from a frame member. Don't let the caliper hang loose. Stress on the brake line may cause the line to rupture.
3. **Pry off the grease cap.** Remove and discard the cotter pin and take off the wheel nut and washer. You should be able to reach in the hub and pluck the outer wheel bearing from its seat. Place all of the parts on a clean sheet of paper.
4. **Screw the wheel nut back on the spindle.** Pull the rotor toward you. The inner wheel bearing and grease retainer will be pushed from the rotor by the wheel nut.

Retrieve the bearing and discard the grease retainer.

5. **Clean and inspect the bearings.** Replace a bearing that is black or cracked, or that binds or scratches when you turn the race.

6. **Use a bearing packer to grease the bearing if it is to be reused.** If you don't have a bearing packer, scoop up a quantity of wheel-bearing grease in the palm of your hand and rub the bearing in the grease until grease oozes from between the bearing needles.

**Note:** Wear clean plastic or rubber gloves when handling bearings.

7. **Install the inner wheel bearing into the rotor.** Position the tapered end toward the inside of the rotor.

8. **Apply a little grease to the inner lip of a new grease retainer.** Then lay the retainer on the inner wheel bearing and use a grease-seal installer to seal the retainer. The tool assures that the seal won't be damaged. If you don't have an installer, use a piece of dowel to tap the seal into place, but be aware that the method is not 100-percent safe.

9. **Put the rotor back on the spindle and insert the outer wheel bearing, washer and wheel-bearing nut.**

10. **Adjust wheel bearings according to manufacturer recommendation.** If this recommendation is not available, use the following procedure:

- As you turn the rotor forward, tighten the wheel nut until the rotor just binds. This action seats the bearings.
- Back off the wheel nut until it becomes "just loose." Then tighten it by hand to make it snug.
- Spin the rotor to make sure it isn't binding.

11. **Loosen the wheel nut, if necessary, so you can insert a new cotter pin.** Bend the ends of the cotter pin against the castellated nut and cut off the extra length.

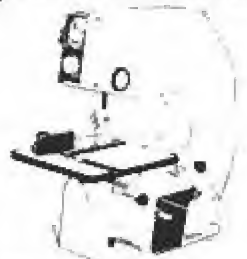
12. **Install the brake caliper, grease cap and wheel-tire assembly.** **PM**

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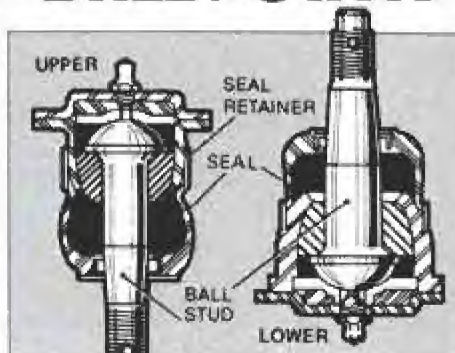
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# 1981 CAR CARE GUIDE

## 48. BALL JOINTS



**Worn or deformed ball joints can't be serviced. They must be replaced.**

**A** worn ball joint will reveal itself by one or more of the following:

- The car pulls to one side.
- The car wanders from side to side.
- A tire wears unevenly (tread may scallop).
- The steering wheel shimmies.
- Steering feels loose.
- Thumping noises come from under the car when going over bumps.

## Inspecting ball joints

Lower ball joints often possess visual wear indicators (lower ball joints in most cars bear the brunt of the load). If lower ball joints in your car have indicators, follow this procedure to determine which components need to be replaced:

**1. Crawl beneath the car.** Don't raise the car since the inspection procedure requires maintaining a load (pressure) on the lower ball joints.

**2. Wipe off the bottom of the ball joint** so the grease fitting and wear indicator are free of dirt.

**3. Scrape your fingernail across the ball-joint cover.** If the round nipple (indicator) is flush with or just below the surface of the ball-joint cover, you will have to replace the ball joint.

If ball joints don't have visual wear indicators, check them for wear by attaching a dial gauge so the gauge stylus touches the bottom of the wheel rim. Load is put on the ball joint by placing a jack at a point specified by the manufacturer on the lower control arm or on the frame.

Motion can then be applied to the wheel-tire assembly with a pry bar to get the reading. If the reading is not in accordance with manufacturer's specification, the ball joint should be replaced.

Removing ball joints requires special tools, such as devices to press parts from their seats. For the infrequent times that you will need these tools, it may be worthwhile to take your car to a professional mechanic instead of tackling this job yourself.

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\*Driver discretion is advised when to use windshield wipers even when Rain-X is applied.

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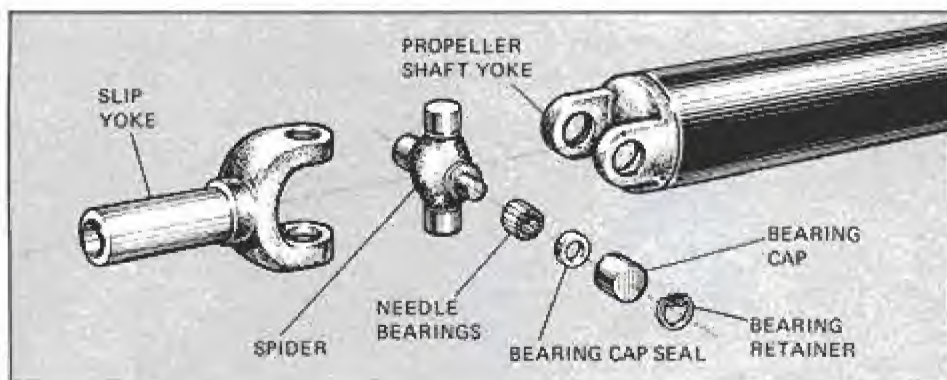
WITHOUT RAIN-X



WITH RAIN-X  
 Which would you rather have?



# 49. U-JOINTS



*Snap-ring pliers will be necessary to remove bearing retainers from U-joint assemblies. Repair and assembly should be carried out on a workbench, not underneath the car.*

**C**ars with rear differentials have a driveshaft that transmits rotary motion from the transmission to the differential. The driveshaft is connected at each point by a universal joint. If the driveshaft is a two-piece unit, there is an additional universal joint connecting the two parts of the shaft.

When a universal joint wears or is broken, one of the following conditions will occur:

- No drive is transmitted to rear wheels.
- A loud rattling is heard at low speeds.
- A vibration is felt at high speeds.

## Replacing a universal joint

Use this procedure as a guide for replacing a bad universal joint:

1. **Using chalk, scribe a reference mark across the driveshaft and differential.** Use this mark when reinstalling the driveshaft to maintain proper driveshaft angularity.
2. **Remove bolts holding the driveshaft to the differential.** Drop the driveshaft so it clears the differential housing and draw the driveshaft to the rear. The front end of the driveshaft will disengage itself from the transmission.
3. **Clamp the driveshaft in a vise.**
4. **Remove the lock rings from the bearing caps of the universal joint.**
5. **Open the vise and place a 1-in. socket against one bearing cap and jaw of the vise.** Place a 1-in. socket against the other bearing cap and jaw of the vise.
6. **Tighten the vise.** This causes the 1-in. socket to push against the universal joint so the opposite bearing cap is pushed out of the driveshaft yoke into the 1-in. socket.
7. **Loosen the vise and pull off the protruding bearing cap.**
8. **Reverse the positions of the sockets and do the same thing to get the opposite bearing cap to protrude from the driveshaft yoke.** Keep doing this until all four caps are removed. Once this is done, the universal-joint cross shaft will fall out, and the driveshaft and driveshaft extension will separate.
9. **Place the cross shaft of a new**

## universal joint into the driveshaft yoke and press on the bearing caps.

This is done by placing a bearing cap in the yoke so it's aligned with the cross shaft and pressing against it with the vise. Keep tightening the vise until the surface of the bearing cap is pressed flush with the surface of the yoke. Do the same to install the other bearing caps.

## 10. Install lock rings when bearing caps are in place.

11. **Force grease into the universal-joint grease fitting until the joint won't accept more.** Use a grease gun.

12. **Carry the driveshaft back to the car.** Align the chalk mark on the driveshaft with the chalk mark on the differential housing and install the driveshaft. Tighten bolts as much as possible.

## Precautions

On some cars with manual gearboxes you must be especially careful when removing the driveshaft. When the driveshaft is pulled out, gearbox oil will come spilling out of the rear of the box and make a mess on your garage floor.

Find out beforehand whether or not this will happen with your car. If it will, drain the gearbox before removing the driveshaft.

When you're working under the car always use jackstands or ramps rated above what is required for the weight of your car.

If you use jackstands just at the rear of the car, make sure you put chocks on the front wheels to prevent the car from rolling. If you jack up all four corners of the car, make sure that the car is lifted the same height all around. In other words, distribute the weight of the car evenly on all four stands; don't let it be lopsided on one end or one side.

A driveshaft that breaks suddenly at the front can create a very dangerous situation if it happens while you're driving. It's called pole-vaulting.

When the front of the shaft drops to the ground it can dig into the road and literally lift up the rear of the car and send it spinning. You should always investigate any noise or rumbling you hear from the driveshaft and fix the problem as soon as possible. **PM**

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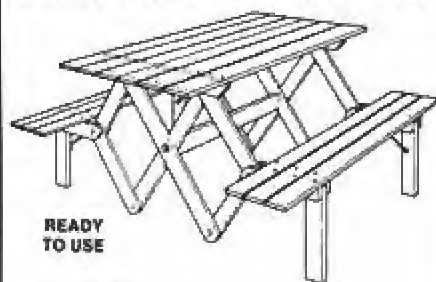
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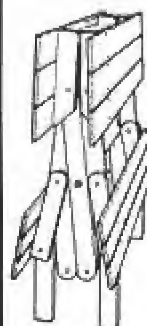
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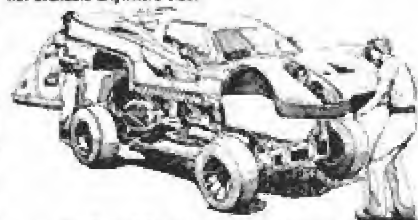
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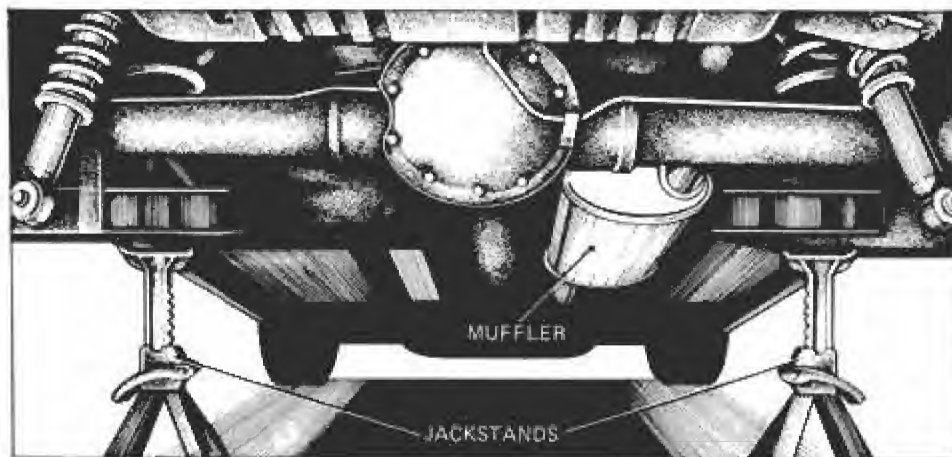
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## 1981 CAR CARE GUIDE

# 50. MUFFLER



**Before you attempt to do any work underneath your car, it's essential that you chock the front wheels and use jackstands that are rated to sustain the weight of your car.**

Inspect the exhaust system periodically to determine if its components are failing. A defective exhaust-system component can allow deadly carbon monoxide gas to enter a car's passenger compartment.

To check the system, you should first inspect the hangers. If they've loosened or have been eaten through by rust, undue stress will be put on the components which will cause their failure prematurely.

Next, look for rust spots on each component and carefully probe these areas with a screwdriver. If rust penetrates deeply into any component, replace that component.

Finally, start the engine and have someone hold a newspaper or wad of rags over the tailpipe opening as you inspect the system from the exhaust manifold to the tailpipe. Hissing or puffs of exhaust from a component tell you that the component is leaking gas. You should replace it.

### Exhaust-system replacements

These guidelines can help simplify and make safe the task of replacing exhaust-system components:

**1. Wear safety goggles to prevent rust or metal shivers from falling into your eyes.**

**2. Make sure that the replacement parts you purchase match the original exhaust-system parts put on the car by the manufacturer.** Your auto-parts and

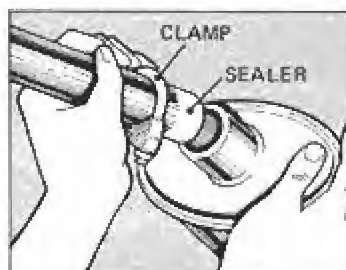
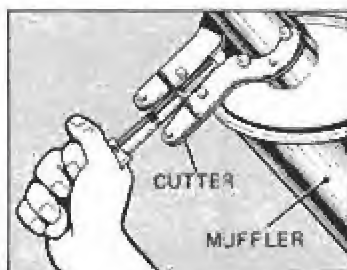
accessories dealer can check his reference file to assure that you get the correct part. Replace only those parts that are bad. You don't have to replace the entire system unless all of it has become defective.

**3. Free parts by applying penetrating oil on joined areas.** Allow oil to soak in overnight. If rusted or corroded fasteners are so badly frozen they won't loosen, cut the defective part free. To remove a bad muffler, catalytic converter or pipe, use a chisel to peel the muffler or catalytic-converter flanges off pipes after removing the brackets, or use a pipe cutter to cut the pipe off at the muffler-pipe weld.

**4. If a pipe is going to be kept in service, use a pipe expander to round out its end.** Then smooth the end with emery cloth. A round, smooth end prevents exhaust-gas leakage by providing for a secure fit when the pipe is joined to a new muffler or catalytic converter.

**5. Coat pipe and muffler joining points with exhaust-system sealer.** Then fit one to the other and clamp. Do not overtighten the clamp. You could crush the joint.

**6. If rust has attacked any hanger so there's a question of its integrity, replace the hanger.** If it fails, the part it holds will drop or bang against an adjacent part. An otherwise good muffler or exhaust-system pipe could be destroyed. **PM**



**To separate the pipe from the muffler, it may be necessary to use a pipe cutter. A cold chisel may work in some cases. When you're joining pipe and muffler, use the right type sealer to stop exhaust leaks.**



# THE TOOLS THAT KEEP THE WHEELS TURNING



*Electronic diagnostic tools will become increasingly important due to the proliferation of automobile computers. A good, multifunction voltmeter that also measures amps, dwell and resistance is a must for any serious mechanic's toolbox.*

If you haven't been doing your own automobile troubleshooting and repair until now, you'll need additional tools and testing equipment as you get more involved. However, don't rush to acquire every tool and tester mentioned in this section. Use the information here as a guide to what's available.

Before doing a job, read all instructions in this *Car Care Guide* (or other service literature) carefully. Then, buy what you need, when you need it.

For example, if you are working with sparkplugs, you may decide to buy a sparkplug cable remover. However, if you own a Chrysler K-car, Ford Escort/Mercury Lynx, GM X-body car or some other 1980-81 models, you don't need a sparkplug cable remover. Manufacturers have provided exceptionally large-sized sparkplug boots that form molded handles for you to grasp and pull.

Once you decide what equipment to buy, don't compromise on quality. This doesn't mean you must always buy the most expensive tool or tester, but don't buy inferior products.

## Start with ordinary tools

You probably already have in your home workshop much of what you need. Common hand tools used for car maintenance and repair are as follows:

■ **Open-end, box and combination wrenches.** In selecting which wrench to use, consider the parts in your car. If a fastener is tight and difficult to remove, use a box wrench. It allows you to apply strong force without

rounding off the corners of the fastener.

If fasteners move easily, use an open-end wrench. It provides speedier loosening and tightening. Instead of having to lift and reposition the wrench, just swing it back to the start position.

A set of 12 open-end and box wrenches, ranging in size from 1/4 in. to 1 3/4 in., will let you handle practically every nut and bolt on most American-made cars prior to 1980 models. If you don't have the size you need in your tool inventory, consider buying a combination wrench (open-end wrench on one side and box wrench on the other side) to give flexibility.

Imported cars and many domestic cars since 1980 use metric size nuts and bolts. For these you need metric-sized wrenches. A full set of wrenches should cover sizes from 6 to 19 mm.

If you have a domestic car with both conventional and metric-sized fasteners (some GM models, for example), you need two sets of wrenches.

■ **Screwdrivers.** You will need flat-bladed and Phillips screwdrivers. Small (say, 1/4-in.), medium (1/2-in.) and large (3/4-in.) flat-bladed screwdrivers will be useful.

In the Phillips category, a No. 2 is the most useful. In time, you may have need for No. 0, No. 1 and No. 3.

■ **Pliers.** Automotive work usually requires two different kinds of common pliers. They are the conventional slip-joint adjustable pliers (6 or 8 in. long) and long-nose (needle-nose) pliers (6 in. long). As you get into more involved

*(Please turn to page 214)*

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## THE TOOLS THAT KEEP THE WHEELS TURNING

(Continued from page 213)

work, you also may need the following types of pliers:

1. *Linesman pliers*.—These are shaped like conventional pliers, but are larger.

2. *Wire-cutting pliers* (nippers).—The name underscores its use. You can buy a pair of conventional slip-joint pliers that incorporates a wire-cutter capability.

3. *Locking pliers*.—They come in various sizes, although 4, 6 and 8 in. long are the most useful. They are indispensable in certain situations, such as squeezing together a rubber hose to prevent fluid from flowing when the hose is disconnected.



A timing light is indispensable. This is one of the first items you should acquire.

■ **Hammers.** Hammers are used for body work or in conjunction with another tool to free an assembly.

The most common hammer used in automotive work is the ball-peen. Get one you can handle—the heavier the better.

A plastic-face hammer is useful for tapping parts that need nudging, but can't take too much force.

### Specialized tools

The following is a list of the most useful specialized hand tools for automotive work:

■ **Ratchet wrench set.** The set includes a ratchet wrench, sockets for general use, sparkplug socket, socket U-joint (to get into spots the straight socket can't) and extension bars. Conventional (inch) and metric varieties are available, but the two are not normally combined in one set.

When deciding on the size ratchet wrench to buy, limit your choice to either  $\frac{3}{4}$  in. or  $\frac{1}{2}$  in. The  $\frac{1}{2}$  in. is heavier and stronger than the  $\frac{3}{4}$  in., but is more expensive.

A set of sockets should cover sizes from  $\frac{3}{4}$  to  $\frac{1}{4}$  in. Extensions that are 3, 6 and 10 in. long will give good versatility.

■ **Flare wrench.** Use this wrench for loosening and tightening nuts that connect fluid-carrying lines, including fuel, brake and power steering.

■ **Allen wrench.** Allen wrenches are L-shaped wrenches with hexagonal-shaped heads that fit holes in fasteners. Each wrench

(Please turn to page 216)



# Gas Saver Tested & Patented

DENVER—The Copley News Service reported that United States Patents have now been issued to Wm. Trevaskis, California veteran electrical engineer, for his Vapor-Jet® brand water vapor injector.

Trevaskis has developed what amounts to a 20 cents per gallon "rebate" potential on gasoline, by designing a low-cost injector for automobiles, light trucks, vans and recreational vehicles.

The Vapor-Jet® system has survived lab testing by a certified independent automotive testing laboratory. Test results showed miles per gallon improvement of 17.3 per cent on Trevaskis' 1971 Ford Galaxy and 13.3 per cent on a 1973 Olds Starfire.

Water injectors were developed to a highly refined state during World War II, to give combat planes increased speed and extended range. However, up to now, the low price of gas and the high cost and extremely difficult installation required for earlier injectors combined to make them unattractive.

The Vapor-Jet® has an unconditional 60 day guarantee.

**How does the Vapor-Jet® system work?**

Vapor-Jet® operates very simply with no moving parts to wear out. It uses engine vacuum to pull outside air through a reservoir containing a water/methanol mixture which is attached to the car under the hood. This causes the fluid to bubble and a mist to form in the upper part of the reservoir. This mist is then drawn by vacuum through a hose which is connected to any intake manifold suction hose. This connection is made very simply by our exclusive hypodermic-like injector nozzle which contains a regulator to allow just the right amount of mist to pass into the combustion chamber.

The introduction of this mist into the fuel air mixture has a cooling effect that increases the mixture density, extends the burning rate, and improves combustion efficiency. This eliminates ping (predetonation) and dieseling (after running of motor). Since steam is a good cleaner it also helps dissolve carbon deposits on the spark plugs and cylinder walls of older vehicles and helps prevent carbon buildup in new ones.



**How much mileage increase can be expected?**

This varies from car to car. Independent testing on Trevaskis' car obtained improvements from 13.3% to 17.3%.

**Will Vapor-Jet® fit all cars and is it easy to install?**

Yes. Vapor-Jet® is easily installed on all domestic and foreign cars, vans, light trucks, R.V.s, campers, motor homes, and small boats. It will work on fuel injection, lean burn cars and cars with turbo chargers and super chargers and rotary engines. It will also work with unleaded gas, gasohol, or propane burning cars. The same kit fits all cars and contains everything needed. Simple installation instructions with a diagram are included and even a novice should be able to install it in less than 10 minutes. Simply take an ice pick or drill and make a small hole through any intake manifold suction hose (i.e.; PCV hose, brake assist hose, vacuum advance hose, etc.). Screw the injector nozzle into the hole, mount the reservoir by means of the bracket and screw supplied and connect the reservoir to the injector nozzle by means of the hose supplied. If you don't want to install it yourself most service stations will for a few bucks.

**Can Vapor-Jet® damage my engine or cause rust?**

Absolutely not! Vapor-Jet® cools down the fuel air mixture giving a better burn and suppresses ping thus aiding your engine. The mist that enters into the engine turns immediately into vapor and exits out the exhaust.

**What is the purpose of the methanol V.I.M. (Vapor Injector Mix) and how long does 1 pint last?**

The reservoir measures 3½" x 5½" x 7½" and holds just under ½ gallon. A full reservoir should last about 1,000 miles. Methanol (wood) alcohol is mixed with water mainly to prevent freezing and to keep the injector nozzle clean in non-freezing weather. The cost of methanol is minimal (about \$5 a gallon). One gallon will last 8,000 miles. Sources of methanol are chemical supply houses, paint stores and drug stores. Substitutes are gas line antifreezes that *contain methanol* such as "Heet" or dry gas.

Further details on Vapor-Jet® may be obtained from Progressive Energy Corp., 3148 So. York, Englewood, Colo. 80110 or contact by phone toll free (800) 525-8624 or in Colorado call (303) 762-1385. For purchase send \$29.95 and \$3.00 for shipping. Dealerships available (Offer void in CA.)



## THE TOOLS THAT KEEP THE WHEELS TURNING

(Continued from page 214)

fits a particular size hole, so you will need more than one wrench.

■ **Hose-clamp pliers.** Use this tool to grasp and squeeze the ends of spring-type hose clamps.

■ **Oil-filter wrench.** Use an oil-filter wrench to loosen an old filter from the engine, so the filter can be removed and replaced with a new one. Be sure to select an oil-filter wrench made for the type of filter used in your car.

■ **Offset screwdriver.** This right-angle-shaped tool enables you to reach screws where not even a stubby screwdriver will fit.

■ **Offset wrench.** This wrench is either right-angle-shaped or arc-shaped. Both can be maneuvered into tight quarters. The working end of the right-angle-shaped tool is in the form of a box wrench. One of its chief uses is to loosen distributor hold-down bolts.

■ **Feeler gauges.** There are two general types of feeler gauges. One is the wire gauge that is used primarily for setting sparkplug electrode gap. The other is a flat-blade feeler gauge used to set the clearance of a number of assemblies, including breaker points and valves.

■ **Gasket scraper.** Use this tool, which has an end shaped like a chisel blade, to remove old gasket material that sticks to surfaces.

■ **Nut splitter.** This tool removes badly corroded nuts that are frozen in place. The tool is placed over the fastener and its bolt end turned, causing the tool's cutter to knife through the stuck fastener.

■ **Hacksaw.** You may also use a hacksaw to cut away frozen fasteners and to cut off rusted exhaust-system pipes.

■ **Torque wrench.** Manufacturers give fastener-tightening specification in either foot-pounds (ft.-lbs.) or inch-pounds (in.-lbs.) torque. Torque wrenches accurately gauge these specifications. One kind of wrench is needed to adjust fasteners to ft.-lbs., while another type is needed to adjust fasteners to in.-lbs.

■ **Ratchet box wrench.** This handy tool has a "slip" just like a ratchet wrench; that is, once in place on a fastener, you don't have to lift and reposition tool to adjust fasteners.



A limited-function dwell/tachometer will perform adequately for basic tuneups.

■ **Impact driver.** Use this tool to loosen frozen screws, nuts and bolts. Place the impact driver on the part you want to loosen, and strike it forcefully with a hammer. The tool may be fitted with flat-bladed or Phillips screwdriver tips. The tool also has a shaft to hold 1/2-in. sockets.

■ **Ignition wrenches.** These short, thin, angular-shaped tools are designed to loosen small nuts holding wire terminals inside a distributor housing.

■ **Pullers.** There are many different-size pullers. Each is designed for pulling off a part that is pressed into place, or can't be removed by other means without damaging an adjacent component.

■ **Wire strippers.** This is a necessary tool when you replace wiring.

■ **Pipe cutters.** Use a pipe cutter to cut away bad exhaust-system parts. Two forms of the tool are available: a chain with cutting teeth and one with an adjustable cutting wheel.

### Lifting tools

Since many components are reached from under the car, give special consideration to tools for keeping the car raised as you work beneath it. Weak, makeshift devices can lead to serious injury. The following are the lifting devices used by most Saturday mechanics:



Special tools like the wheel puller won't be used often, but they're useful to have. When you really need them, nothing works better.

■ **Heavy-duty scissors jack.** Use this tool, rather than the weak, wobbly bumper jack provided by the manufacturer, to raise your car.

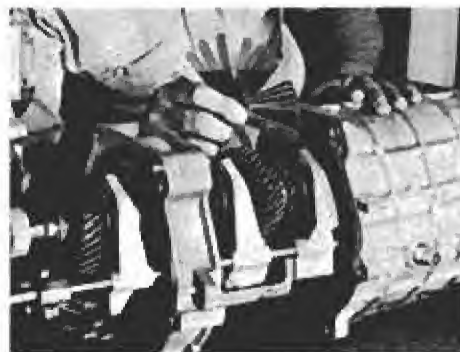
To raise the front of a car that has a rear differential, set the parking brake and place an automatic transmission in PARK or a manual transmission in REVERSE. To raise the rear of a car that has a rear differential, block the front wheels with chocks. You can purchase chocks or make them from pieces of 4 x 4 lumber, beveled on one edge. Even heavy stones or cinder blocks can serve as chocks.

**Note:** Reverse the procedure above for a front-wheel-drive vehicle.

■ **Jack stands.** Use jack stands to support the vehicle when wheels must hang free—for example, when removing a tire and wheel to work on brakes or wheel bearings.

■ **Ramps.** Use ramps when wheels don't have to hang free—for example, when changing oil, lubricating ball joints or draining the radiator.

■ **Crepper.** Use this board-on-coasters to move under the car. A crepper also makes it easier to maneuver while you're under the car.



Feeler gauges are essential. They're good for a variety of critical measurements.

### Testers to think about

Various instruments, from simple mechanical tire gauges to sophisticated electronic engine testers, are available to help determine the condition of assemblies in cars.

■ **Tire gauge.** The chief cause of premature tire failure is incorrect inflation. You can't tell if inflation is correct without a tire gauge.

■ **Compression gauge.** An engine that is losing pressure from one or more cylinders gives poor performance and fuel economy.

One type of compression gauge is hand-held. It is pressed into sparkplug ports as the engine is cranked. Sometimes it becomes awkward to use this tool, especially when a cylinder is in a spot that prevents you from exerting full force against the gauge. Compression can then leak from around the gauge's snout, giving a false compression reading.

Another type of compression gauge has a threaded adapter that screws into sparkplug ports to keep the gauge in place. This self-held gauge is more expensive than the hand-held, but it is more accurate. There is no compression loss if the adapter is properly engaged.

■ **Vacuum gauge.** A vacuum gauge measures engine vacuum. Since overall engine performance depends on the right amount of vacuum under various speed and load conditions, the vacuum gauge can help you determine the functioning of several systems. They include the valve train, fuel system, ignition system, and head and manifold gaskets. Many vacuum gauges are integrated with a fuel-pump pressure tester into one instrument.

■ **Battery hydrometer.** This instrument measures the state of battery electrolyte and, therefore, the ability of a battery to accept and retain a charge.

■ **Coolant hydrometer.** This tool shows if the coolant is able to protect your engine at temperatures encountered in your area.

■ **Radiator pressure tester.** The radiator pressure tester helps the Saturday mechanic locate a cooling-system leak. It also indicates if the radiator pressure cap is in good condition.

■ **Tachometer.** This records engine speed in revolutions per minute. It is needed to set carburetor idling, ignition timing and distributor point dwell.

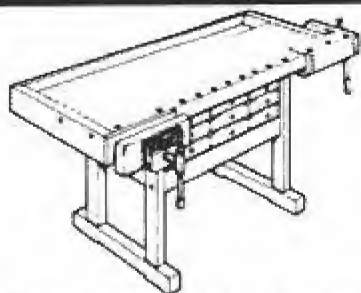
■ **Power timing light.** You need this light to set the ignition timing of an engine.

■ **Dwellmeter.** In cars with a conventional (breaker point) ignition system, the dwellmeter is necessary for setting breaker point dwell; that is, the length of time points are closed. The dwellmeter and tachometer are frequently combined in one tool, but you can buy one without the other.

FM



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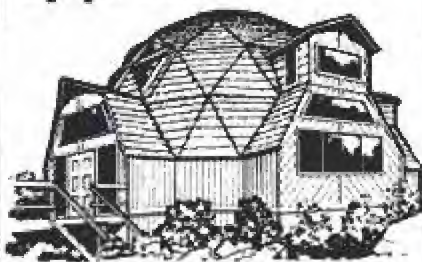
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# CAR RECALLS

In May 1979, *Popular Mechanics' Car Care Guide* first presented a summary of safety-related recalls made under the notification and remedy section of the National Traffic and Motor Vehicle Safety Act. Your response indicates the usefulness of this information.

The initial report covered recalls from 1965 to 1978 involving cars made by American Motors, Chrysler, Ford and General Motors. We updated the list in the Car Care Guide of May 1980.

This year we are expanding the feature with a list of late-model recalls reported by major foreign-car manufacturers.

If you find your car mentioned in this list, call this toll-free hot-line number of the National Highway Traffic Safety Administration: 800-424-9393. Describe the nature of the recall you think may apply to your car. You will receive a card. Fill it out, being sure to include the vehicle identification number, and send it to the car manufacturer. You will receive word whether the recall applies to your car.

## DATSUN

| Year/Units<br>Models Involved        | Description of Defect<br>Corrective Action  |
|--------------------------------------|---|
| 1975: 31,615<br>280Z                 | Metal fuel-system clamps may deform, cause leak due to loss of uniform clamping. Replace clamps.  |
| 1975-76: 389                         | Fuel-system hose may deteriorate. Replace hose.   |
| 1975-79: 295,710<br>280Z, 280ZX, 610 | Gum may accumulate in air regulator due to defect in PCV system and cause prolonged high idle in cold weather. Install new PCV valve, reroute crankcase hose and correct problem in the air regulator and throttle chamber. |
| 1980: 15,019<br>310                  | Main-shaft locking nut may loosen, causing hard shifting or inoperable transmission. Tighten nut.   |

## HONDA

|                                |  |
|--------------------------------|--|
| 1974: 66,109<br>Civic          | Front seat-belt assembly may not meet federal standard. Modify.                            |
| 1975-77: 132,573<br>Civic 1200 | Muffler may deteriorate, allowing exhaust gases to escape into car. Install muffler cover. |
| 1977: 33,552<br>Civic          | Short circuit in choke system may cause choke cover to burn. Modify.                       |

## MAZDA

|                             |   |
|-----------------------------|---|
| 1974: 2,218<br>RX-4         | Power-steering system defect may exist. Replace gear-box assembly.                              |
| 1974: 8,422<br>Pickup truck | Exhaust-pipe protector may become deformed. Install new protector.                              |
| 1976: 9,137<br>RX-3, 808    | Fuel-system check-valve pipe may be improperly installed. Modify.                               |
| 1976: 2,034<br>RX-3         | Plug in carburetor may fail, cause fuel leak in vehicles with manual transmission. Reseal plug. |

(Please turn to page 221)

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The Datsun truck story comes your way from Nissan Motor Corp., pioneer of the compact pickup truck in America. A full-size, full-color catalog features their complete line. Learn about the NAPS-Z engine, 4 x 4's, diesels and how to personalize your pickup with exciting options. Free

## 416 Oil Data

Dade Products offers product specifications sheets on Multi-Lube which include latest independent performance test reports. Free

## 417 More Power to Your Car

Normark Manufacturing would like you to know that you can now add power door locks and power windows to your car. Full-sized, 8-page brochure describes these power features and other automotive accessories designed for easy do-it-yourself installation. Free

## 418 Save Your Body & Money Tool

POPULAR MECHANICS/MOTOR BOOKS offers a complete guide to keeping your car looking like new—Bodywork & Painting. Fully illustrated. Step-by-step photos and color diagrams show how to do most jobs yourself without expensive equipment. Full-color sections on fixing rust-outs, dents, plus spraypainting and custom techniques by the experts. 240 pages. \$9.95

## 419 Tune-Ups Made Easy

Informative new booklet from Wells Mfg. Corp., makers of automotive electrical and ignition system parts, gives step-by-step instructions for tuning your car. Printed in English and Spanish. Includes detailed information on electronic ignition systems for most late model cars, as well as a section on conventional ignition systems for older models and imports. Free

## 420 Cycle Instrument Catalog

VDO-ARGO Instruments offers a full-color catalog explaining the function of their VDO combination handlebar/fairing gauges, and how to use these touring instruments for safer, more pleasurable biking. Also Biker and Enduro instruments, plus crazy poster offers. Free

## 421 Magical Cleaner

Blue Magic wants you to try their metal polish cream to see how it can beautify and protect metals and hard plastics. Sample, decal and catalog brochure are all free.

## 422 Good Connections Count

Check your car wiring with the Auto Cable Tester and spot bad connections, poor grounds and lack of continuity. Kit includes instructions. You only supply the battery. From POPULAR MECHANICS PROJECT LIBRARY. \$2.95

## 423 Used Cars With Warranties

Avis sells late-model used cars. Choose from GM's, Toyotas and many others. Most cars are backed by a free 12-month, 12,000 mile (whichever comes first) Limited Power Train Warranty. Maintenance histories available. Brochure and store directory are free.

## 424 Manifold Economy & Performance

Edelbrock's newest brochure lists their replacement intake manifolds for domestic V8, V6, in-line 6-cylinder and import car 4-cylinder manifold engines. Learn how a bolt on replacement can improve your vehicle's performance and mileage. Free

## 425 How to Make Time

You can easily make clocks for fun, extra income or for gifts. Fully illustrated, free 32-page catalog includes quartz clock movements, dials, numerals, and accessories at super low prices. From Klockit.

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### SUBARU

|                                   |   |
|-----------------------------------|---|
| 1976-77: 42,256<br>Station wagon. | Tailgate may not latch properly. Install new latch assembly.                                |
| 1977-78: 170,000                  | Engine may stall at minus 20° F. and below. Install new PCV system.                         |
| 1977-79: 83,000<br>Station wagon. | Cracks may develop in fuel tank. Modify.  |
| 1978: 23,000<br>Brat.             | Leak may exist in fuel tank. Modify fuel-evaporation control system.                        |
| 1980: 71,683                      | Defect in windshield-wiper assembly may render wipers inoperative. Install new master link. |

### TOYOTA

|  |  |
|--|--|
| 1977-79: 79,392<br>Corolla.                    | Inadequately torqued steering-gear box worm-gear locknut may cause instability. Correct.               |
| 1978: 5,700<br>Corona.                         | Defective fuel-system pressure-relief valve may fail, cut off fuel and cause engine to stall. Replace. |
| 1978: 5,317<br>Hi-Lux.                         | Side body-panel welds may not conform to federal standard. Inspect and correct.                        |
| 1980: 98,493<br>Celica, Corona, Corolla truck. | Alternator pulley may break. Replace.  |

### VOLKSWAGEN

|  |  |
|--|--|
| 1974: 3,000<br>Type 181.                                 | Improper joining of constant-velocity joint surfaces may have taken place. Repair.   |
| 1974-76: 219,000<br>Dasher, Rabbit, Scirocco.            | Accelerator cable may fail, result in loss of control. Install new cable.  |
| 1975: 16,000<br>Type 1.                                  | Loose injector clamps may exist, result in fuel leak. Change clamps.   |
| 1975: 3,500<br>Scirocco.                                 | Brake-pedal pin-lock plate may have been installed improperly. Repair.   |
| 1975: 1,760<br>Type 1.                                   | Rear-axle shaft may snap. Replace.   |
| 1975: 68,000<br>Rabbit, Scirocco.                        | Roller bearing in steering-gear box may become dislodged and cause loss of steering. Modify.   |
| 1975-79: 680,000<br>Rabbit, Scirocco.                    | Improperly sealed antenna cable may let water enter fuse relay board, activate starter. If the transmission is left in gear, the car may move. Seal holes; inspect fuse board—replace if corroded. |
| 1977: 1,700<br>Beetle convertible.                       | Tailight lens reflectors may be installed improperly. Replace left and right lenses.   |
| 1977-78: 14,750<br>Van, Bus, Kombi, Camptmobile, Pickup. | Steering-system swing-lever shaft may break, causing loss of steering. Install new shaft.  |
| 1978: 18,500<br>Rabbit, Scirocco.                        | Throttle-valve body housing-to-brake booster pump rubber elbows may fail, causing loss of power-assisted brakes. Install new elbows and clamps.  |
| 1978: 1,126<br>Dasher.                                   | Disc-brake caliper bolts may be improperly torqued, causing brake noise and vibration. Retorque.   |
| 1978: 3,000<br>Rabbit.                                   | Vacuum line between carburetor and thermo valve may be improperly installed, preventing return of throttle valve to idle. Modify.  |
| 1980: 2,572<br>Vanagon.                                  | Improperly torqued ball-joint bolts may exist, lead to separation of ball joint and upper wishbone member. Retorque.   |
| 1980: 2,287<br>Vanagon.                                  | Defective auxiliary heater exhaust may be fire hazard. Install new pipe.   |

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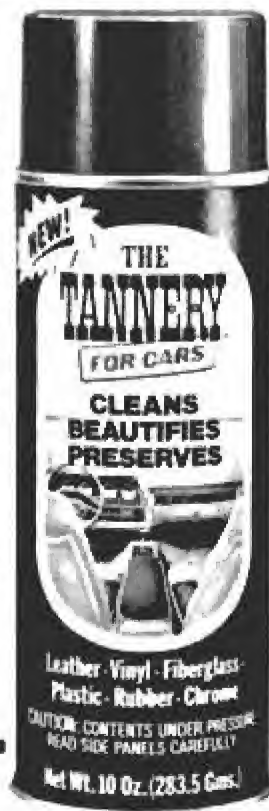
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## HAT TRICK AT INDY

(Continued from page 103)

new four-cylinder Offenhauser, Shaw broke race records, but barely edged second-place finisher Ralph Hepburn by 2.16 seconds.

For the 500 in 1939, Shaw's sponsor acquired an eight-cylinder su-

## EXOTIC POWERPLANTS

(Continued from page 101)

ers feel that the move to stock blocks will ultimately increase, rather than decrease, the cost of fielding a car at Indy.

Hard-core hot rodders, of course, are overjoyed at the decision, especially the devotees who have venerated the many variations of the basic Chevy powerplants that have been around since 1955. As if to get a head start on the new rules—and maybe they even helped push them along—several Chevy-based engines ran in the 1980 500.

Rookie Roger Rager qualified 10th fastest, using an engine that had been built up from a block taken from an old school bus. And, of course, the USAC/CART sprint and dirt track cars, as well as the World of Outlaws unlimited racers, have been using Chevies for years.

But comparing any of these engines, even those running the NASCAR Grand National engine is comparing apples to oranges. A GN engine has 366 inches, a four-barrel carburetor, a flat-tappet cam, and runs on gasoline.

"The Indy engine would use injectors, run on methanol and turn at much higher revs," says Rutherford. "Other things would be done to reach the full power potential, but they'd also decrease reliability. The big difference is the use of alcohol and injectors." Gasoline engines use a fuel-air mixture that runs about 16 pounds of air for every pound of fuel. Alcohol, on the other hand, is consumed at a rate of about 8 pounds of air for every pound of fuel. Since an engine's volumetric efficiency is based on the volume of air it can ingest per revolution, the consumption of fuel will double, but the power will increase with alcohol. Alcohol also permits higher compression ratios and its cooling properties permit the engine to be turned faster. But faster turning stock blocks need better lubrication systems. That means the whole oiling system has to be modified and improved with exotic dry-sump oiling systems. This will add even more to the cost.

In practical terms at Indianapolis, the result is about 20 percent more power at a cost of much higher fuel consumption, greater stress on the engine, and a resultant loss of reliability. Getting that reliability back will cost plenty.

Rutherford thinks the match between the normally aspirated, 355-inch engine and the turbocharged 209 is "lopsided." He figures the 209 is good for a five mph advantage in qualifying speeds on the 2¼-mile oval at Indy. But four hot laps on the track is a different proposition from 200 laps in traffic.

By then, Ford may have gotten the racing bug again and may join the party by throwing several million into developing a racing version of some stock block the Cleveland foundry is churning out. But even the most sophisticated rocker-box that Detroit can come up with is still a question mark. Or, as Andreotti says, "The 500 should be for thoroughbreds!"

We agree.—P.B.

percharged Maserati. With it, Shaw dominated the race for the next three years. He picked up his second and third checkered flags in '39 and '40, and was on his way to a third straight victory in '41 when a wheel broke on the 152nd lap and put him out of the race. He never competed in another race at the Speedway again.

The winner that year was Mauri Rose, who had taken over Floyd Davis's Noc-Out Hose Clamp Special (love that name) after his own car had quit with sparkplug trouble on the 60th lap. That ride was the beginning of a long and successful partnership between Rose and car-builder Lou Moore, a former driver.

If Shaw had dominated the race in the immediate prewar days, the Mauri Rose-Lou Moore combination "owned" the 500 from 1947 through 1949. In those three races, the team, with drivers Bill Holland and George Connor, took three firsts, two seconds and a third. In 1947, Holland was running first and Rose was second with fewer than 10 laps remaining when Moore signaled "EZY" from the pits. Holland obeyed, Rose didn't, passing Holland to take top money. The following year, in the same Moore-designed, front-drive, Offy-powered cars, Rose and Holland finished one-two again, making Rose the Speedway's third three-time winner. In 1949, Holland finally took top honors himself, new teammate George Connor finished third in a rear-drive Moore car, and Rose finished 13th, going out at 192 laps while running second because of a broken magneto strap.

By 1950, Rose had left the team, but Holland took second again, while the other Moore cars finished sixth, eighth and 31st. Rose finished third in a brand-new front-drive car, the Howard Keck Pennzoil Special.

## And then there's Foyt

If Wilbur Shaw could be said to have dominated the 500 in the 1930s, Mauri Rose the '40s, Bill Vukovich the '50s, then there's only one name to apply to the '60s and the '70s—A.J. Foyt.

Foyt first raced at Indianapolis in 1958. He will start his 24th 500 this year. He's won the race four times, placed second twice, third three times, held the pole four times and has led 12 races. He has 2,500 more miles in competition at the Speedway than the nearest competitor, the late Cliff Bergere.

Foyt's career spans two eras at

Indianapolis—that of the rugged, Offy-powered roadsters and that of the present rear-engined cars. Fittingly, his first victory came in 1961, the same year that British World Champion Jack Brabham finished ninth in the Speedway's first successful rear-engined car. There were three more roadster victories, including Foyt's in 1964, before the rear-engined cars assumed their leadership at Indy.

Foyt soon learned to live with the rear-engined cars and he won again in 1967.

Ten years passed before he won again, but in the meantime, he continued to prove his all around mastery, winning the 1972 LeMans 24 hour race with codriver Dan Gurney, adding three more USAC national championships and the 1972 Daytona 500 to his personal records.

## Underrated Unser

Chief mechanic for Foyt's 1961 win, as well as the next one in 1964, was George Bignotti. A strong personality in his own right, Bignotti left Foyt after a dispute in 1965 to aid Graham Hill's 1966 winning debut at Indy. Then, in 1970, Bignotti became chief mechanic for the so-called "Super Team" assembled by retired driver Parnelli Jones, winner of the 1963 race. Drivers on the team were Joe Leonard, who became USAC National Champion in 1970 and 1971, and Al Unser, who won the 500 in 1970 and 1971.

Unser could easily be described as "the driver nobody knows," and is probably the most consistently surprising and underrated of the current group of drivers who have won at Indy.

At one point in his career he won four 500-mile races in a row—the season-ending Ontario 500 in 1977 and, in 1978, the Indy, Pocono and Ontario 500s. He is easy on his equipment and, as the odds-makers say, "can go the distance if his car holds up."

Texas millionaire race driver, designer and car builder Jim Hall entered a British-built Lola in the 500 at Indy in 1978, and hired Al Unser to drive it. In the car, Unser scored his third and Hall's first Indianapolis win.

The following year, Hall brought a new car of his own design to the Speedway. The car was a giant leap into the future, and featured a carefully sculptured underbody that used the Bernoulli, or ground, effect

(Please turn to page 224)



## HAT TRICK AT INDY

(Continued from page 223)

to help it hug the track. Starting in the front row, Unser ran away with the race until the 104th lap, when a transmission seal failed. During the remainder of the 1979 season, similar failures plagued the car, leading to a breakup between Hall and Unser.

### Johnny Rutherford

Hall then signed on a fellow Texan, Johnny Rutherford, for the 1980 season. Together, they not only won the 500, but set a record for the number of competitive miles run consecutively in one season by a single car. The reliability that had been missing the year before had been found.

It took Rutherford 11 races before he won his first 500-miler in 1974. The next came two years later in the rain-shortened '76 race. Rutherford was in the lead when the race was stopped and then later ruled complete after 102 miles. He was teased endlessly about winning the Indianapolis 255-mile race. But in 1980, there was no question—the race had been his virtually from the day the track had opened for the first practice.

Rutherford has proved to be a popular winner, much like Wilbur Shaw. He's been able to capitalize on his fame through endorsements, and is good-looking and articulate enough to be a convincing pitchman on television. Again, in 1981, he'll have the best equipment available. Best of all, from his point of view, the slightly upgraded Chapparral will, this year, have a bright red No. 1 painted on its nose.

Entered in the 1981 race with the Chapparral are many new ground-effect cars. Most will be powered with Cosworths equipped with a new Switzer turbocharger that should correct a problem apparent in the 1980 race.

The new turbocharger is larger, and thus will provide more air at lower speeds, so that there's less of a lag in the response. A new pop-off valve has also been developed by the USAC to assure adherence to the 48-inch limit.

Thus, the last year of the "pure" racing engines at Indy will be like so many of the years that have gone before. The circle is complete. The best (and most expensive) equipment will go to the drivers who've proved they can perform. That means mostly Cosworth engines; few will gamble with next year's unknown, when last year's sure thing is available.

PM

## SIX NEW WAYS TO GET BETTER SOUND

(Continued from page 106)

control the exact amount of expansion. The Pioneer unit lets you choose different preset levels.

But we particularly liked the tri-level display of the 3BX. Three beautiful rows of LEDs monitor high, low and mid-frequency ranges. Red LEDs show how much louder a passage is being enhanced; yellow LEDs, how much softer. This unit may make your stereo look like a *Buck Rogers* set, but it will make your music sound like heaven.

### Digital delay

Ever been to a live concert in an auditorium or theater? If you have, you know the special audio "feel" of live music. Music reverberates around you, blanketing you via the hall's own acoustics. It's an interplay among the singer's voice, the hall's nooks and crannies, and your own ears.

In a living room, you get little chance to appreciate such a sound—unless you use a digital delay like the Koss K/4DS unit (\$459).

The K/4DS comes with two little speakers that you position behind you—but the resemblance to the late, unlamented quadraphonic sound ends there.

The 4DS calculates what the echoes and reverberations would sound like in one of four "environments": club, theater, concert hall and auditorium. These echoes and acoustical enhancements are added to your music to simulate that "live" feeling.

Of course, this can be overdone. Too much enhancement can make music sound like it's coming from the far end of a Middle Eastern pipeline. But used as it is intended, the effect is phenomenal. The room seems to open out around your ears.

### Imagers and holographers

More computer-age technology is evident in the Omnisonic Imager (\$189) and the Carver Stereo Holograph Generator (\$867). Both take normal stereo signals and process them. The result: Sound seems to come from far more than just two speakers.

The processing is done by computer. The computer samples a bit of sound from each of the two stereo speakers. Then it mixes the sound to

imitate the way that music projected from a concert stage would mix naturally.

The Imager widens the stereo "stage." Instead of your music sounding as if it were coming from just a foot beyond your speakers, it now comes from an imaginary, curved proscenium that stretches in front of you like an actual stage. You can hear the placement of instruments and follow the movements of musicians.

The Carver Sonic Holograph is similar in effect, but even more exact. Close your eyes and you'll have no doubt as to where each musician you are hearing is "placed."

We found the Carver equipment to be fairly easy to hook up, even though the instructions warn that it may take several hours to get everything just so. We used a special test record (\$8.95), available from Carver Corp., Box 664, Woodinville, Wash. 98072. (The record also includes some preprocessed sound that will play on any system so you can get a good idea of holographic sound.)

### Decoders

Surface noise has always been my pet peeve. Regardless of stereo or record quality, I can still hear that blasted hiss.

Dbx has come up with a system that obliterates surface noise—at least as far as I could hear. The dbx Decoder (\$109) is used with specially processed records. Only trouble is, these special records (marked "dbx encoded disc") can be hard to find. But we predict you will soon see more selections available as people realize their worth.

### Tiny headphones

I used to hate to wear headphones. Even the lightest, high-velocity-type phones made me feel as if my head were in a vise.

There are now many small—and good—headphones on the market. The .5s (pronounced Point Fives) we tried from Audio-Technica (\$85) sounded fabulous. We even experienced the deepest bass from these headphones that look like toys—but sound great. Other fine little headphones are available from Sony, Sansui, Pioneer and others.

(Please turn to page 226)



Carver's new C9 unit (\$279) allows you to add sonic holography to any stereo system.





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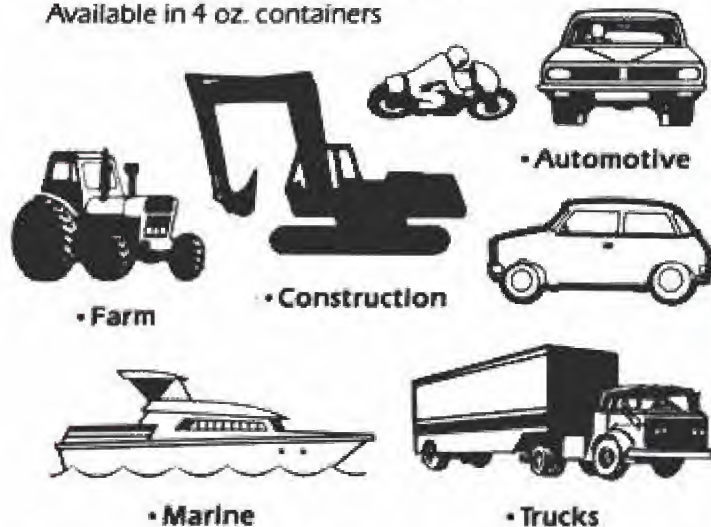
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## BETTER SOUND

(Continued from page 224)

Ever since electronics began, a power supply has been a cumbersome system with big filter capacitors and a hunk of iron called a transformer.

Then along came Carver Corp. with its M400 amplifier. It has 400 watts of power—and is only 7 inches square. It set the audio world—the entire electronics field—on its collective ear. An output of 400 watts from a 7-inch box was like something out of *Alice in Wonderland*.

Carver had applied things like inductive storage of energy to the



M400 from Carver set the industry on its ear: 400 watts—and just 7 inches square.

audio field. And the results were great. Not only were the supplies smaller, but they were more responsive to musical demands.

Soon, other companies picked up on similar technology. And now audio is changing.

Yamaha has come out with a line of components using what it calls the X-power supply. One is a high-wattage pyramid that stands less than a foot high. The same power supply is used in the Yamaha A-760 amplifier that we tried out. It ran cool and easy, even at full output.

## Living in the aftermath

When the testing was over and it was time to return the units to their manufacturers, we switched off the Koss Digital Delay and our concert hall collapsed back into a living room. We undid the dbx expander and the music became dim and hollow. We turned off the Omnisonic Imager and the sound became dead and lifeless.

We stared in horror at the stereo set we had loved only a week ago. It hulked there, its squawking voice but a dim reminder of the glories it had only recently achieved with those amazing add-ons.

## BUILDING PM'S SAILBOARD

(Continued from page 113)

angles to it—11 inches at the bow, 17 inches at the stern and 27 inches at the beam midway between the two. Take a springy piece of 1×2 or similar material, weight it so it follows the curve formed by each set of points, and trace the contours onto the plywood. This will give you the profile of the deck and bottom.

Note that the hull curves up slightly, forming a 4-inch rise starting at a point 42 inches aft of the bow. Lay out this curve on the 1-inch side stock, again using a springy piece of material to establish a smooth-flowing upward sweep. Cut the sidepieces and attach them to the plywood bottom, using waterproof glue and noncorrosive flathead screws. Shape the center spine to the same bow curve.

The pointed bow block is shaped from 2×4 stock laid flat. The ¾-inch-square stringers on the underside of the deck provide reinforcement along the after portion of the hull where your feet go. These are cut so they straddle the spine and fit just inside the sides. When installing the deck, first apply glue to the ends of the stringers. This way, the stringers will be glued securely inside the hull.

## Mast, boom and sail

The mast is simply a 14-foot length of ready-made molding used for handrails on stairways. This comes preshaped to an oval cross section—ideal for a strong, yet gracefully slim mast. A universal joint, made by interlocking the heads of a screw eye and eyebolt, anchors the mast to the hull and permits it to tilt in any direction. The mast is attached by inserting the eyebolt through a hole in the hull, with a locknut on the underside. Use an additional nut and washer above the deck under the eye for a bearing.

Unlike conventional sailboat booms, the wishbone shape used on sailboards is designed to straddle the sail at shoulder level. This gives you a handgrip for controlling the sail from either side in a stand-up position. The two sides of the boom are flexed to an oval shape by bolting them to angled end blocks as shown. The boom is lashed to the leading and trailing edges of the sail with cord threaded through grommets.

The sail is made of ripstop polyethylene, available at marine suppliers as plastic tarpaulin material. Start by laying out the 81° angle at the clew and the two free edges. This will establish the triangular shape. No sewing is required, as all edges are taped. At the two trailing edges, rope is rolled into the seams for stiffening. A pocket in the leading edge slips over the mast.

To finish the hull, use a sealer made for plywood, then follow with several coats of marine enamel in a bright color. Nonslip deck material, sold at boat stores, can be added to give you a firm footing.

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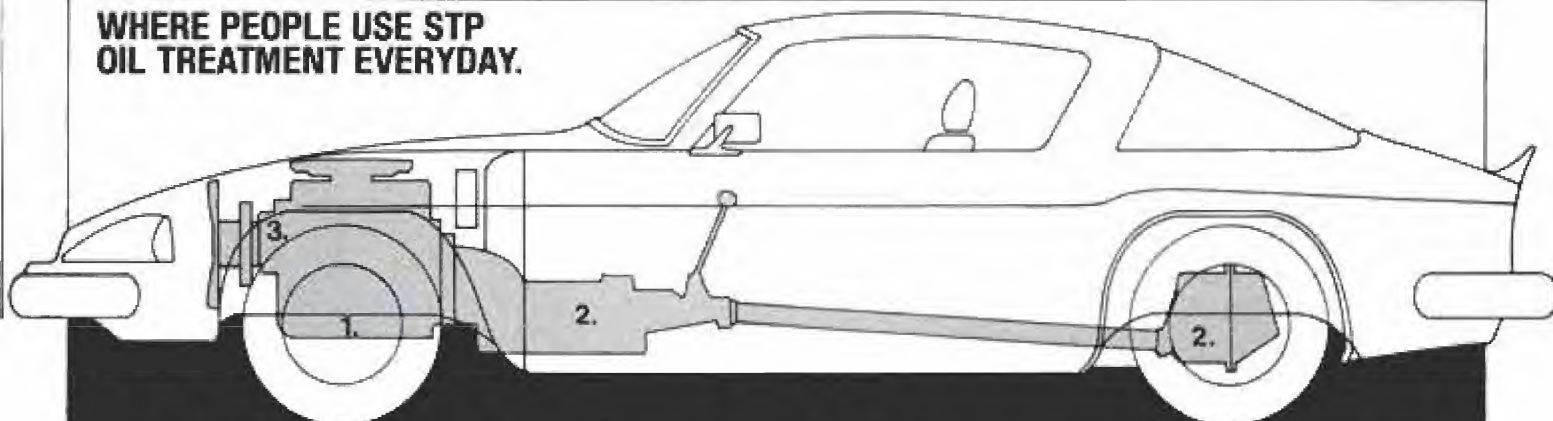


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**1. Your engine's crankcase.** The first time you need oil and every time you change oil add STP Oil Treatment when the engine is running and warmed up. Use one can of STP Oil Treatment to 4 or 5 quarts of oil. Maintain 10% by volume.

**2. Manual transmission, gear boxes and differentials.** Add one part STP Oil Treatment to 10 parts regular lubricant. For trucks and tractors, add up to 1 part STP Oil Treatment to 6 parts of lubricant. (Not recommended for use in friction drives and wet clutches.)

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**Engine assemblies.** If you work on your engine, coat all moving engine parts prior to assembly with a mixture of 1 part STP Oil Treatment and 1 part motor oil.

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but it's comfortable, easy to handle, economical and retains its value better than most. Six people can ride in this car and they'll all still be talking to each other at the end of the day."

An Illinois architect: "This is my sixth Cad and it's a great car. It has no peer in terms of looks and comfort. It commands that extra-special little attention at parking

garages or when police direct traffic and so on."

A Florida retiree: "I like the variable-displacement V8-6-4 engine. It gives me power when I need it for safety and on four cylinders, it's quiet and economical. True, the engine tends to be a little rough as a V6, but it very rarely operates that way, so I really have no complaints."

A Texas investor volunteered that "in my opinion, Cadillac represents the best buy on the road today—and you can quote me on that!"

And finally, a retired Minnesotan handed the car its ultimate compliment in the form of a rhyme: "It's a Cadillac, the very best. Would I buy another? Yes, yes, yes!"

## SUMMARY OF 1981 CADILLAC SEDAN DEVILLE OWNERS REPORTS\*

|  |   |                                       |   |
|--|---|---------------------------------------|---|
| <b>Total miles driven</b> 816,741        | <b>Styling</b> 36.3                       | <b>Comfort opinion (front seats):</b> | <b>Dealer service opinion:</b>              |
| <b>Average miles per gallon</b>          | <b>Ride</b> 29.2                          | <b>Excellent</b> 62.2%                | <b>Excellent</b> 41.4%                      |
| <b>Ohv V8</b>                            | <b>Handling</b> 28.2                      | <b>Very good</b> 24.8                 | <b>Good</b> 29.1                            |
| <b>In town</b> 17.5                      | <b>Economy</b> 19.7                       | <b>Good</b> 10.6                      | <b>Average</b> 8.7                          |
| <b>Long trips</b> 22.0                   | <b>Performance</b> 17.1                   | <b>Fair</b> 2.4                       | <b>Fair</b> 9.7                             |
| <b>Diesel ohv V8</b>                     |   | <b>Poor</b> 0.0                       | <b>Poor</b> 10.1                            |
| <b>In town</b> 21.5                      | <b>Specific dislikes:</b>                 | <b>Comfort opinion (rear seats):</b>  | <b>Number of vehicles owned:</b>            |
| <b>Long trips</b> 27.9                   | <b>No complaints</b> 31.4%                | <b>Excellent</b> 58.8%                | <b>Cadillac Sedan DeVille only</b> 29.7%    |
| <b>Variable-displacement V8-6-4</b>      | <b>V8-6-4 engine performance</b> 18.4     | <b>Very good</b> 25.2                 | <b>Two cars</b> 51.6                        |
| <b>In town</b> 14.2                      | <b>Poor workmanship</b> 10.0              | <b>Good</b> 11.9                      | <b>Three cars</b> 13.3                      |
| <b>Long trips</b> 19.2                   | <b>Fuel mileage below expectation</b> 9.5 | <b>Fair</b> 3.1                       | <b>Four or more cars</b> 5.5                |
| <b>Engine choices:</b>                   | <b>Car noises and rattles</b> 9.1         | <b>Poor</b> 0.9                       | <b>Makes of other cars owned:</b>           |
| <b>Ohv V6</b> 12.4%                      | <b>What changes would you like?</b>       | <b>Had any mechanical trouble?</b>    | <b>Chevrolet</b> 31.7%                      |
| <b>Diesel ohv V8</b> 10.1                | <b>No changes</b> 19.2%                   | <b>No</b> 54.0%                       | <b>Oldsmobile</b> 17.6                      |
| <b>Variable-displacement V8-6-4</b> 77.4 | <b>Refine the V8-6-4 engine</b> 13.6      | <b>Yes</b> 46.0                       | <b>Cadillac</b> 14.4                        |
| <b>Why did you choose Sedan DeVille?</b> | <b>Better fuel mileage</b> 9.1            | <b>What type of trouble?</b>          | <b>Ford</b> 13.9                            |
| <b>Owned Cadillacs before</b> 43.0%      | <b>Better quality materials</b> 7.1       | <b>Oil leaks</b> 18.3%                | <b>Buick</b> 11.7                           |
| <b>Styling</b> 17.5                      | <b>Better workmanship</b> 7.1             | <b>V8-6-4 engine computer</b> 13.9    | <b>Age distribution of owners:</b>          |
| <b>Comfort</b> 12.0                      | <b>Workmanship opinion:</b>               | <b>Transmission with V8-6-4</b> 12.2  | <b>15-29 years</b> 0.8%                     |
| <b>Size</b> 10.0                         | <b>Excellent</b> 37.1%                    | <b>Electrical system</b> 10.4         | <b>30-49 years</b> 22.3                     |
| <b>Ride</b> 5.2                          | <b>Good</b> 37.5                          | <b>Cruise control</b> 7.8             | <b>50-plus</b> 76.8                         |
| <b>Economy</b> 5.2                       | <b>Average</b> 13.7                       | <b>Dealer repairs satisfactory?</b>   | <b>Would you buy another Sedan DeVille?</b> |
| <b>Specific likes:</b>                   | <b>Fair</b> 5.5                           | <b>Yes</b> 55.2%                      | <b>Yes</b> 93.3%                            |
| <b>Comfort</b> 48.7%                     | <b>Poor</b> 6.2                           | <b>No</b> 44.8                        | <b>No</b> 6.7                               |

\*Percentages might not equal 100% due to rounding or insufficient data.

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## 4 GREAT PLAYTHINGS

(Continued from page 230)

axles and paint boom/arm parts, then reassemble.

### Making truck sides

Stack two pieces of 3/4-in. stock and lay out, band saw and bore holes as shown on page 120. Round all edges with a router and rounding-over bit except the sides adjoining the roof and front grille, and inside the bottom edge. Rout 1/4-in.-deep recesses to simulate cab windows.

Assemble strengthening cleats to the bottom and sides, using waterproof glue and nails. Assemble in the same way the blocks for the pivot rod through the base and vertical cleats inside the truck sides at trunnion and cab. Rebore the 1/2-in. hole for the body pivot not quite through the block.

From 3/4-in. stock, cut out the grille, front bumper, two chassis skirts, two skirt spreaders and foot pedal. The seat should be of 1-in. hardwood with the grain running across the truck. Round all corners and edges where appropriate, and assemble parts with waterproof glue and finishing nails. Imitation lights and grille ornaments were added on the prototype.

### The wheels and bucket

Band saw four 5-in. blanks from 2-in. stock. For turning, glue sandpaper to a wood faceplate to act as a friction drive. Place a blank against the sandpaper and bring up the dead center to engage the compass detent at the center of the blank. Turn the tire and face of the wheel, then bore the 1/2-in. axle hole. Paint the tires black, the wheels as you prefer.

Aluminum sheet 1/2-in. thick is available at scrap-metal yards or duct-fabrication shops. Lay out bucket parts according to the drawing. Cutting can be done on a band saw as aluminum is softer than the woodcutting blade.

Drill 1/4-in. holes for the yoke rods. Bending is done on a small brake clamped to the circular-saw table. You could do a suitable job with a machinist's vise and hammer. Make the bends and assemble the back to the bucket with cold rivets.

Assemble the bucket to the yoke with two 1/4-in. rods threaded at both ends. The front rod has nuts on the inside of the bucket and on outside faces to prevent collapsing and spreading. Bucket sides at the front rod must be slightly sprung to install the front rod with internal nuts in place.

Assemble the yoke to the end of the arm with 1/4-in. rod threaded at

both ends, a tube spacer and washer on each side of the yoke, and nuts on the outside at rod ends. Mushroom rod ends slightly to keep nuts tight. Assemble the arm and boom with 1/4-in. rod and pushnuts. Assemble the boom to trunnions on the truck with 1/4-in. rod, pushnuts, washers and spacers.

### Installing the foot pedal

Make the foot pedal 2 1/4 in. wide by 5 in. long from hardwood stock 1 in. thick. The pedal controls the attitude of the bucket. Even when boom and arm levers move, a consistent position of the pedal holds the position of the bucket. Changing the bucket attitude responds well to movement of the pedal.

Drill the pedal through its width for the 1/4-in. rod that will pass through the lower part of the truck trunnions and accept the hardwood pedal on one end. Tap the rod into the pedal flush with the edge, then pin it with an 8d finishing nail in a hole drilled through pedal and rod. Looking toward the rear from the

front, pass the rod through the right trunnion and slip on a 2 1/2-in.-dia. sheave. Pass rod end through the left trunnion and install a pushnut. Do not pin sheave to the rod until the cable is run.

Determine cable lengths by running string through and around the sheaves. Looking aft, the shorter cable on the right connects the sheave glued to the operating lever with that glued to the arm, operating the arm. The longer cable interconnects the four sheaves on the left—pinned sheave on the foot-pedal rod, two idlers at ends of the boom and small sheave glued to the bucket yoke. This controls the bucket attitude. Use string as guides to cut cable lengths.

Airplane cable of 1/8-in. diameter should be found at an industrial hardware store. Pull cable loosely around the sheaves and through locking holes, and adjust sheaves by rotating them to allow proper turning leeway. Start at lowest sheaves, leaving 10 or 12 in. of cable loose for turnbuckle attachment under boom.

Tighten lock screws (sheet-metal screws with points ground flat) at these lower sheaves before final routing of the cable. Attach cable ends to the turnbuckles with double-hole swedges (crimp-on cable clamps) appropriate for 1/8-in. cable (an industrial hardware store should have them). Here, a swedging tool was made with holes drilled in a flat bar, and a hacksaw cut made through the centers of the holes.

Check and adjust sheave rotational positions for leeway in movement and cable tightness before you tighten the lock screw on the outboard sheave. If cable holes in any sheaves are too large, insert one or two short pieces of cable in the hole. Adjust arm lever to arm position before locking it. Repeat the procedure for the bucket-control cable from foot pedal. Holes in idler sheaves must be large enough for two thicknesses of cable. Attach swedged loops to turnbuckles, tighten cables.

### Finish assembly

With parts prepainted and truck-boom assembly completed, pivot the truck body to the chassis. Cut a pivot pin from 1/2-in.-dia. steel rod, to a length just short of the depth of both holes plus the washer. A waxed leather disc was used on the prototype; metal discs will serve as thrust washers. A small chain anchored by a screw under the roof has an end snap hook to engage a screw eye on the boom. It acts as a snubber to lock the boom in traveling position.

—Emery J. Loisel

(Please turn to page 232)

### MATERIALS LIST—BOY-POWERED DIGGER

| Key | No. | Size and description (use)                                      |
|-----|-----|---|
| A   | 4   | 1 3/4 x 5'-dia. hardwood (wheels)                               |
| B   | 1   | 2 x 2 1/2 x 5 1/2" hardwood (pivot block)                       |
| C   | 1   | 1 1/2 x 5 1/2 x 20" hardwood (truck base)                       |
| D   | 1   | 1 1/2 x 5 1/2 x 21" hardwood (chassis base)                     |
| E   | 1   | 1 1/2 x 2 x 5 1/2" hardwood (chassis pivot block)               |
| F1  | 1   | 1 x 2 x 10" hardwood (boom lever)                               |
| F2  | 1   | 1 x 2 x 10" hardwood (arm lever)                                |
| G   | 1   | 1 x 2 3/4 x 5" hardwood (foot pedal)                            |
| H   | 1   | 1 x 7 1/2 x 8" hardwood (seat)                                  |
| I   | 1   | 1 x 1 3/4 x 8" pine or hardwood (bumper)                        |
| J   | 2   | 3/4 x 7 1/2 x 20" pine or hardwood (truck sides)                |
| K   | 2   | 3/4 x 3 1/2 x 21" pine or hardwood (chassis sides)              |
| L   | 1   | 3/4 x 2 1/4 x 13 3/4" pine or hardwood (boom web)               |
| M   | 1   | 3/4 x 1 1/2 x 13 1/2" pine or hardwood (arm web)                |
| N   | 1   | 3/4 x 2 x 4" hardwood (bucket yoke)                             |
| O   | 1   | 3/4 x 4 x 7" pine or hardwood (grille)                          |
| P1  | 2   | 3/4 x 1 1/2 x 5" pine (cleats)                                  |
| P2  | 2   | 3/4 x 1 1/2 x 6" pine (cleats)                                  |
| Q   | 2   | 3/4 x 2 x 6" pine (chassis cleats)                              |
| R   | 4   | 3/4 x 2 1/2'-dia. hardwood (sheaves)                            |
| S   | 1   | 3/4 x 3'-dia. hardwood (sheave)                                 |
| T   | 1   | 3/4 x 2'-dia. hardwood (sheave)                                 |
| U   | 2   | 3/4 x 2 1/2 x 18 1/4" plywood (boom side)                       |
| V   | 1   | 3/4 x 2 1/2 x 18 1/4" plywood (arm side)                        |
| W   | 1   | 3/32 x 3 1/4 x 13 1/2" aluminum (bucket)                        |
| W1  | 1   | 3/32 x 3 1/4 x 5 1/2" aluminum (bucket back)                    |
| X   | 1   | 1/2"-dia. x 5" steel rod (truck pivot)                          |
| Y   | 1   | 3/4"-dia. x 5" steel rod (pedal pivot)                          |
| Z   | 2   | 3/4"-dia. x 11 1/2" steel rod (sides)                           |
| AA  | 1   | 1/2"-dia. x 1 1/2" steel rod (boom pivot)                       |
| BB  | 1   | 1/4"-dia. x 3 1/2" steel rod (arm pivot)                        |
| CC  | 3   | 1/4"-dia. x 5" threaded steel rods (bucket and pivot spreaders) |
| DD  | 2   | 5/8"-i.d. x 1 1/4" metal or plastic tube (spacers)              |
| EE  | 1   | 1/2"-i.d. 3'-o.d. leather washer                                |
| FF  | 5   | 1/4"-dia. cold rivets   |
| GG  | 4   | 3/4"-i.d. flat washers  |
| HH  | 1   | 3/8" pushnut  |
| II  | 4   | 5/8" pushnuts   |
| JJ  | 4   | 1/2" pushnuts   |
| KK  | 1   | 1/4-20 hex nut  |
| LL  | 1   | 8d finish nail cut to 1" (pedal pin)                            |
| MM  | 1   | 1/4"-dia. x 4" steel rod (lockpin)                              |
| NN  | 1   | 1/8" steel airplane cable (20 ft.)                              |
| OO  | 2   | Turnbuckles   |
| PP  | 4   | Double-hole swedges   |
| QQ  | 6   | No. 6 x 1/2" sheet-metal screws                                 |
| RR  | 2   | 1/2" screw eyes   |
| SS  | 1   | 16" sash chain with snap hook                                   |
| TT  |     | No. 8 x 1/2" rh screws  |
| UU  |     | 4-40 x 1/2" rh screws and washers                               |



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(Continued from page 231)

## Sleek model racer with roll bar

Cut the wheels out of a piece of 6/4 pine stock. As this stock measures 1 1/2-in. thick, boring from both sides is required because the typical hole saw penetrates only 3/4 in. deep.

Cut the body from a piece of 2x4. Use a band saw or a rip handsaw to cut the long taper. Drill 3/16-in. dia. holes for the lagscrew axles and 1/16-in.-dia. holes for the roll bar. Drill the axle holes from both sides unless you have a long drill bit.

Paint the wheels and body. Select a suitable plastic bubble from a hardware package and carefully remove the backing. The bubble shown contained brads mounted on cardboard. Cut a cowl from 1/8-in. plywood or stiff cardboard, sized to fit over the bubble flange. Paint it, then nail it into place.

For a sporty touch, apply striping tape of a contrasting color.—Lui Zaninovich

### MATERIALS LIST—RACER

| Key | No. | Size and description (use)                    |
|-----|-----|---|
| A   | 1   | 1 1/2 x 3 1/2 x 13" 2x4 fir (body)            |
| B   | 4   | 1 1/2 x 1 1/2-in. dia. 6/4 pine (wheels)      |
| C   | 1   | Plastic bubble from hardware package (canopy) |
| D   | 1   | 1/8" plywood (cowl)                           |
| E   | 1   | 3/16 x 2 1/2" U-bolt (roll bar)               |
| F   | 8   | 3/4-in. l.d. washer                           |
| G   | 4   | 1/4 x 2 1/2" lagscrews                        |
| H   |     | Striping tape (as reqd.)                      |



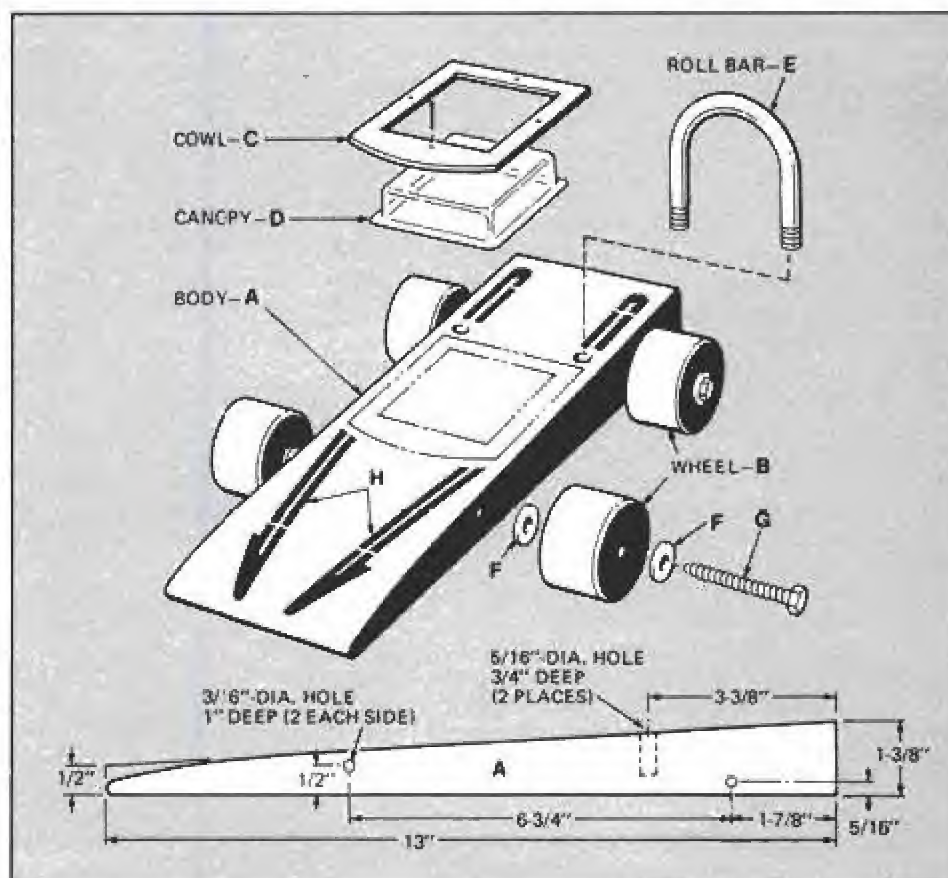
Using a 2-in. hole saw in a drill press, you cut the racer wheels from 6/4 stock.



Sand wheels and check for fit. Accessories for car include U-bolt, plastic bubble.



Vinyl striping tape has pressure-sensitive backing. Decorative strips come precut.





## Play-center TV for youngsters

**C**ut the plywood to size, then draw three rectangles for the cutouts. Draw three straight lines the length of the top and side of the smaller opening and the side of the large opening. Drive in one nail at each end of these lines. Place the flexible guide against the standing nails, then deflect it  $\frac{1}{2}$  in. at the center and trace the line.

Bore 2-in.-dia. holes tangent to the outline to form the round corners and make the cuts with a sabre saw.

Carefully cut the  $\frac{1}{2}$ -in.-wide slots



Flexible rule is used to draw the pattern for the curved cutouts. Rule is deflected  $\frac{1}{2}$  in. at center to obtain the required curvature.



Thin cardboard templates simplify the layout of the cutting lines for the openings.



Holes made with a 2-in. hole saw form corners of the cutouts. If made with a portable drill, be sure you clamp workpiece.



Flathead screws and finishing washers are used to attach backboards and shelf. Painting is best done with parts disassembled.

| MATERIALS LIST—PLAY TV |     |   |  |
|------------------------|-----|---|--|
| Key                    | No. | Size and description (use)  |  |
| A                      | 1   | $\frac{1}{2} \times 48 \times 52$ plywood (frame)                         |  |
| B                      | 2   | $\frac{1}{2} \times 12 \times 24$ plywood (foot)                          |  |
| C                      | 1   | $\frac{1}{2} \times 3 \times 19$ plywood (shelf)                          |  |
| D                      | 2   | $\frac{1}{2} \times 4 \times 5$ plywood (shelf end)                       |  |
| E                      | 2   | $\frac{1}{2} \times 1 \times 5$ plywood (shelf cleat)                     |  |
| F                      | 1   | $\frac{1}{2} \times 19 \times 38$ cork-faced Homasote (bulletin board)    |  |
| G                      | 1   | $\frac{1}{2} \times 19 \times 23$ chalkboard                              |  |
| H                      | 2   | $\frac{7}{8} \times 44$ wood outside corner-guard molding (frame edging)  |  |
| I                      | 1   | $1\frac{1}{2} \times 19$ wood outside corner-guard molding (shelf edging) |  |
| J                      | 1   | $8 \times 10$ mirror  |  |
| K                      | 1   | 24" shade with brackets   |  |
| L                      | 3   | Dial knobs, Amerock T-594   |  |
| M                      | 1   | No. 6 countersunk washers   |  |
| N                      | 14  | $\frac{1}{4}$ " No. 6 fl. screws  |  |
| O                      | 4   | $\frac{7}{8}$ " No. 6 fl. screws  |  |
| P                      | 16  | 1" No. 6 fl. screws   |  |
| Q                      | 1   | 4d finishing nails  |  |
| R                      | 4   | Coat hooks (self-sticking plastic type)                                   |  |

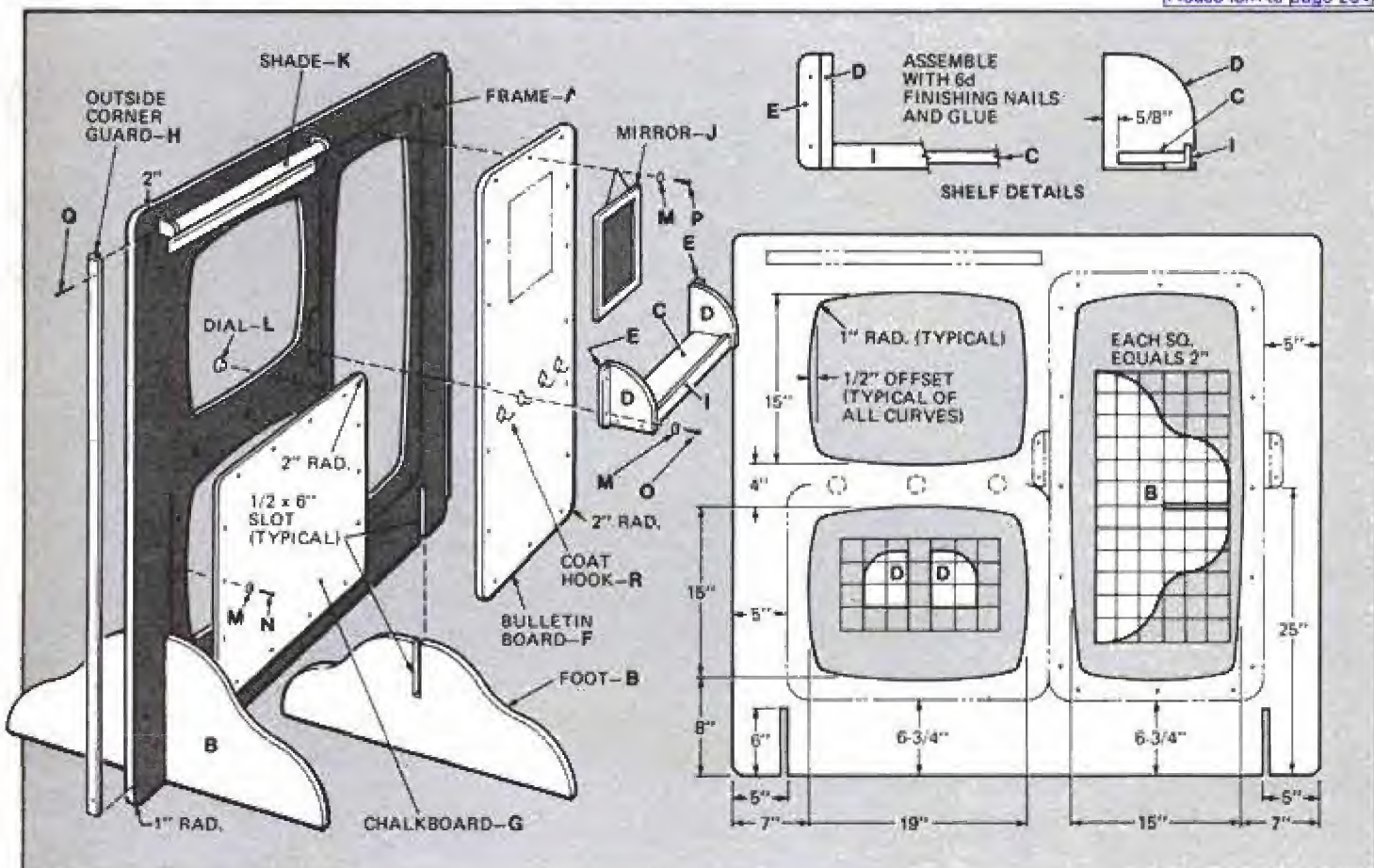
at the bottom of the board and in the tops of the base pieces to produce neat interlocking joints.

Sand and paint all the parts before assembly. Use a chalkboard paint on the hardboard. Use flathead screws with finishing washers to attach the

hardboard and bulletin board. The shelf is attached last. We used Amerock T-594 knobs for the TV "controls."

Self-adhering plastic clothing hooks are attached to the Homasote bulletin board.—Harold Rogers

(Please turn to page 234)





(Continued from page 233)

## 18th-century doll cradle

**S**elect a piece of warp-free 1x12 pine and draw on the cradle sides. Make the bevel cuts along both edges of the board before cutting out the sides so you will have a straight edge to ride the fence. Cut the 35° bevel on the tops, then smooth all exposed edges except the bevels.

Next, cut the footboard, headboard, canopy support and rockers. Then cut the canopy parts to size with the appropriate bevels. To make your work easier, all these parts should be sanded before assembly.

To assemble, glue and nail the sides to the footboard and headboard, using 6d finishing nails. Pre-drill pilot holes before nailing. Attach rockers to the bottom, then join the bottom to the sides. Attach the



A 7° bevel is cut along both edges of the board. Note that, after you have cut one side, the board must be flopped before cutting the second edge to insure that the bevel angle is properly positioned.



The 35° bevel on the top of the cradle sides is cut after pieces have been separated.



Hand-screw clamps are good for steadying project during assembly. Start the nails, then lift the section off and apply glue.



Rockers are preattached to the bottom, then bottom to the sides. Don't overdo the glue; use it sparingly, as shown above.

### MATERIALS LIST—DOLL CRADLE

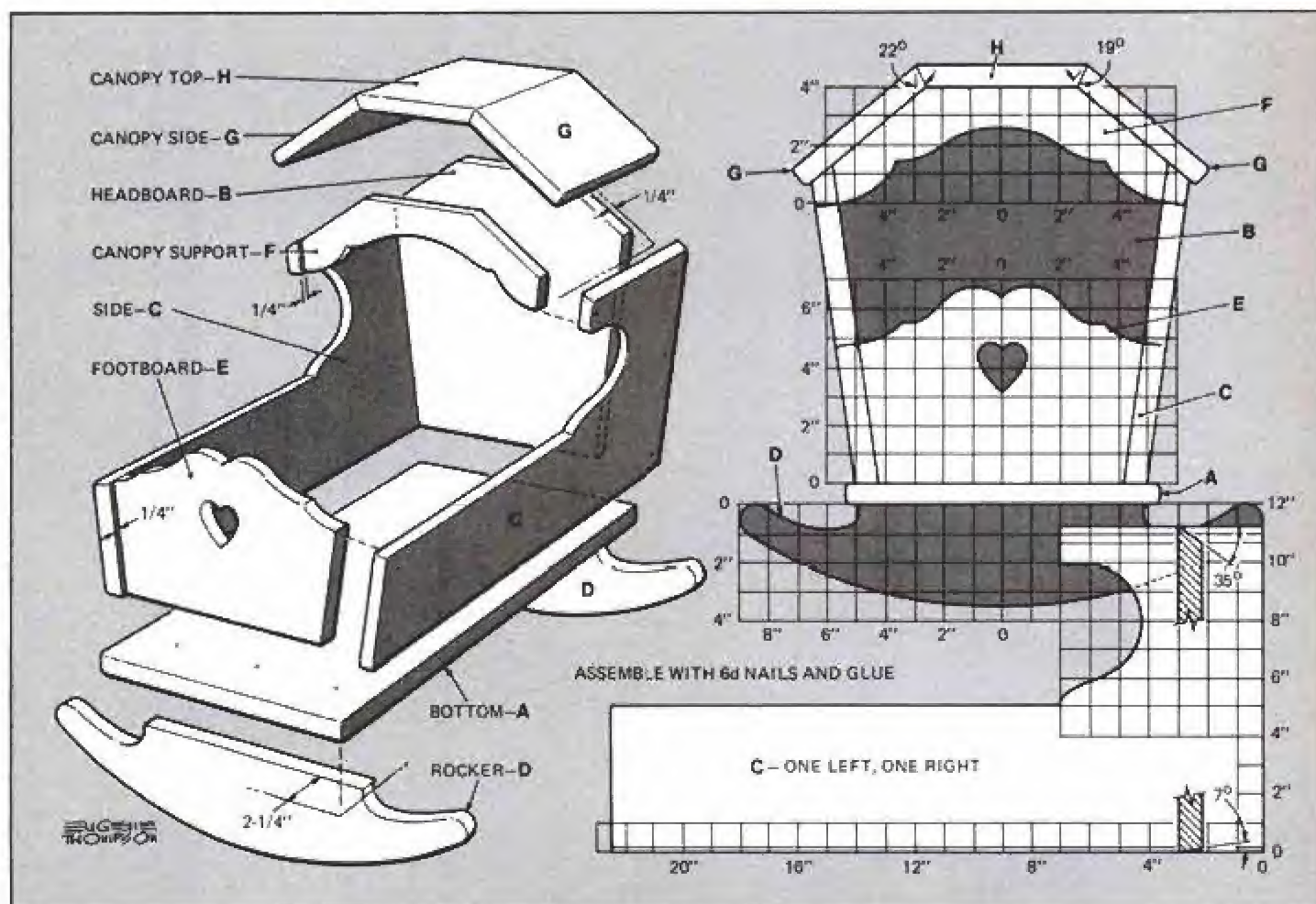
| Key | No. | Size and description (use)                  |
|-----|-----|---|
| A   | 1   | 3/4 x 10 3/4 x 22 1/2" pine (bottom)        |
| B   | 1   | 3/4 x 11 1/4 x 13 1/4" pine (headboard)     |
| C   | 2   | 3/4 x 11 1/4 x 22 1/2" pine (sides)         |
| D   | 2   | 3/4 x 3 1/2 x 18 3/8" pine (rockers)        |
| E   | 1   | 3/4 x 6 3/4 x 9 3/4" pine (footboard)       |
| F   | 1   | 3/4 x 3 3/4 x 11 1/4" pine (canopy support) |
| G   | 2   | 3/4 x 5 9/16 x 6 7/8" pine (canopy side)    |
| H   | 1   | 3/4 x 5 3/4 x 6 7/8" pine (canopy top)      |

Misc.: 6d finishing nails and glue.

canopy support and the canopy pieces. Set all nailheads and fill indents with wood putty.

We obtained an antique finish using ordinary stain. Apply a diluted coat of sanding sealer, let it dry,

then sand lightly. Next, wipe on a satin stain and stroke it lightly with a cloth to produce a grained effect. Allow twice the normal drying time, then finish with polyurethane varnish.—Robert Lewis





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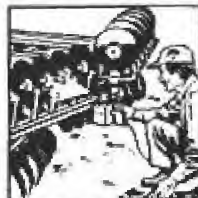
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## YOU BE THE JUDGE

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